

# High-speed CMOS Logic Data Book

1984

Silicon-gate  
Complementary MOS



TEXAS  
INSTRUMENTS



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# High-speed CMOS Logic Data Book

EDITH MARSH

High-speed CMOS logic is a new technology that offers a wide range of performance advantages over other logic technologies. This book provides a comprehensive overview of the technology, including a detailed description of the internal structure of CMOS logic devices, a comparison of CMOS logic with other logic technologies, and a detailed description of the various CMOS logic devices available from Texas Instruments. The book also includes a detailed description of the various CMOS logic devices available from Texas Instruments, including a detailed description of the various CMOS logic devices available from Texas Instruments.



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# High-Speed CMOS Logic Data Book

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## INTRODUCTION

The high-speed silicon-gate CMOS logic family (SN54HC/SN74HC) from Texas Instruments offers a broad range of functions: from basic gates and flip-flops to bus-compatible complex devices. These devices are pin-for-pin and functionally compatible (but not necessarily interchangeable) with the corresponding devices in the popular LSTTL family. Also, many of the metal-gate CMOS devices (4000 series) and TTL-voltage-compatible functions ('HCT) are available in the high-speed CMOS logic family from Texas Instruments.

The original CMOS devices were used in applications where the main concerns were low power consumption, wide power supply range, and high noise immunity. These requirements were satisfied by the metal-gate CMOS family. However, metal-gate CMOS could not satisfy system designs that required high speeds such as those imposed by microprocessor-based applications. For such designs, the system designers used faster families (STTL and LSTTL), and thus traded the advantages of CMOS for faster switching speeds. With the introduction of the high-speed CMOS family, Texas Instruments now provides the system designer with the best of both TTL and CMOS; fast switching speeds (comparable to LSTTL) and most of the advantages of CMOS.

The drawbacks of metal-gate CMOS arise because the source and drain areas are diffused before the gate is defined (Figure 1), and therefore the metal gate needs to overlap the source and drain to allow for misalignment, resulting in higher gate capacitances. Junction capacitance is increased by the deep diffusions required for the source and drain. The slow switching speeds are a result of the combined gate and junction capacitances.

New generations of CMOS technology (high-speed CMOS or HCMOS) have now evolved through improvements in process technology. High speeds and low power consumption have been made possible by the  $3\text{-}\mu\text{m}$ , self-aligned poly-silicon-gate CMOS process. In this process, poly-silicon gates are deposited over the gate oxide before the source and drain implants are made (Figure 2). Then the gate itself is used as a mask for the source and drain implants. This self-aligning process results in reduced gate capacitance. Junction capacitance, a function of the junction area, is also minimized on a per gate basis through shallower implants and minimal sideways diffusion. The net result is an increase in the switching speeds. An added benefit of the self-aligning feature is that it permits smaller channel lengths, hence smaller gates and less gate capacitance. This corresponds to higher gate densities and further reduction in power consumption.

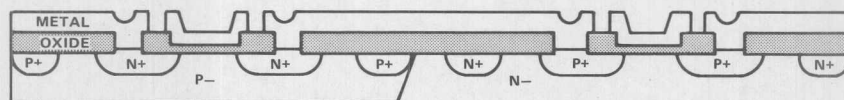


FIGURE 1. METAL-GATE CMOS

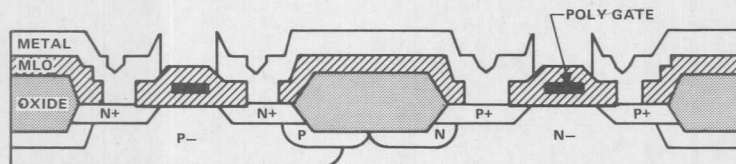


FIGURE 2. HIGH-SPEED SILICON-GATE CMOS

Designers' Information (Section 7) provides detailed discussion of interchangeability, electrostatic discharge (ESD) protection, latch-up circuitry, design considerations, interfacing, and other pertinent subjects regarding this family.



#### ATTENTION

These devices contain circuits to protect the inputs and outputs against damage due to high static voltages or electrostatic fields, however, it is advised that precautions be taken to avoid application of any voltage higher than maximum-rated voltages to these high-impedance circuits.

Unused inputs must always be connected to an appropriate logic voltage level, preferably either  $V_{CC}$  or ground.



FIGURE 1. METAL GATE CMOS



FIGURE 2. HIGH SPEED METAL GATE CMOS



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# 1

## GENERAL INFORMATION



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<sup>‡</sup>See these pages for description, pin assignments, timing requirements, and switching characteristics.

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## 1 GENERAL INFORMATION

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Quad D-type Flip-Flops with Common Clocks	Complementary	Common Clear	'HC175			3-143
		Output Enable	'HC379	3-263		
Hex D-type Flip-Flops with Common Clocks	Q only	Common Clear	'HC174	IV	2-10	3-143
		Output Enable	'HC378			3-263
Octal D-type Flip-Flops with Common Clocks	Q only	Common Clear	'HC273			3-233
		Output Enable	'HC377			3-263
	3-State, Q only	Output control	'HC374			III
			'HC574	3-303		
	3-State, $\overline{Q}$ only	Output control	'HC534	4-69		
'HC564			3-287			
Octal D-type Flip-Flops with Common Clocks and TTL-Compatible Inputs	3-State, Q only	Output control	'HCT374	VII	2-14	4-55
			'HCT574			3-307
	3-State, $\overline{Q}$ only	Output control	'HCT534			4-73
			'HCT564			3-291



DUAL J-K FLIP-FLOPS

DESCRIPTION	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
		TABLE	PAGE	
Dual J-K Flip-Flops with Clear	'HC73	II	2-6	4-3
	'HC107			3-51
Dual J-K Flip-Flops with Preset	'HC113			3-63
Dual J-K Flip-Flops with Preset, Common Clock, and Common Clear	'HC78			4-5
	'HC114			3-65
Dual J-K Flip-Flops with Preset and Clear	'HC76			3-45
	'HC112			3-59
Dual J-K Flip-Flops with Preset and Clear	'HC109			3-55

BUS DRIVERS AND TRANSCEIVERS WITH 3-STATE OUTPUTS

DESCRIPTION	OUTPUT DATA	CONTROL INPUTS	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
				TABLE	PAGE	
Quad Bus Drivers/Receivers	True	Individual Enables	'HC125	III	2-8	3-69
			'HC126			3-69
Quad Bus Transceivers	Inverting	Independent Enables	'HC242			3-201
	True	for A and B Buses	'HC243			3-201
Hex Bus Drivers/Receivers	True	Common Enables	'HC365			3-251
	Inverting		'HC366			3-251
	True	Symmetrical Enables	'HC367			3-251
	Inverting		'HC368			3-251
Octal Bus Drivers/Receivers	Inverting	Symmetrical Enables	'HC240			3-191
		2 Enables	'HC540			4-77
	True	Complementary Enables	'HC241			3-191
		Symmetrical Enables	'HC244			3-207
Octal Bus Transceivers	Inverting	Independent Enables for A and B Buses	'HC620			3-315
			'HC623			3-315
	Inverting		'HC640			3-319
	True and Inverting	Enable and Direction Control	'HC643			3-319
			'HC645			3-319
	True		'HC245			3-213
Octal Bus Transceivers with Registers	True	Enable and	'HC646			3-329
	Inverting	Direction Control	'HC648			3-329
	Inverting	Independent Enables	'HC651			3-341
	True	for A and B Buses	'HC652			3-341
Octal Bus Drivers with Registers	Inverting	Independent Enables for A and B Buses	'HC7340			4-157
8-/9-Bit Bus Transceivers with Parity Checker/Generator	True	Enable and	'HC659			3-353
	Inverting	Direction Control	'HC658			3-353
	True	Independent Enables	'HC665			3-367
	Inverting	for A and B Buses	'HC664			3-367

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#### BUS DRIVERS AND TRANSCEIVERS WITH 3-STATE OUTPUTS AND TTL-COMPATIBLE INPUTS

DESCRIPTION	OUTPUT DATA	CONTROL INPUTS	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION	
				TABLE	PAGE		
Quad Bus Transceivers	Inverting	Individual Enables	'HCT242	VII	2-14	3-203	
	True	for A and B Buses	'HCT243			3-203	
Octal Bus Drivers/Receivers	Inverting	Symmetrical Enables	'HCT240			3-195	
		2 Enables	'HCT540			4-81	
	True	Complementary Enables	'HCT241			3-195	
		Symmetrical Enables	'HCT244			3-211	
		2 Enables	'HCT541			4-81	
Octal Bus Transceivers	Inverting	Independent Enables	'HCT620			4-93	
	True	for A and B Buses	'HCT623			4-93	
	Inverting	Enable and Direction Control	'HCT640			3-325	
	True and Inverting		'HCT643			3-325	
	True		'HCT645			3-325	
			'HCT245			4-19	
Octal Bus Transceivers with Registers	True	Enable and	'HCT646			3-335	
	Inverting	Direction Control	'HCT648			3-335	
	Inverting	Independent Enables	'HCT651			3-347	
	True	for A and B Buses	'HCT652			3-347	
8-/9-Bit Bus Transceivers with Parity Checker/Generator	True	Enable and	'HCT659			3-361	
	Inverting	Direction Control	'HCT658			3-361	
	True	Independent Enables	'HCT665			3-375	
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#### ASYNCHRONOUS (RIPPLE-CLOCK) COUNTERS

DESCRIPTION	FEATURES	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
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7-Bit Binary Counters		'HC4024	IV	2-10	3-395
12-Bit Binary Counters		'HC4040			3-399
14-Bit Binary Counters		'HC4020			3-391
	On-Chip Oscillator	'HC4060			3-403
Dual Decade Counters	Biquinary or BCD	'HC390			3-269
	Set-to-9 input	'HC490			3-275
Dual 4-Bit Binary Counters		'HC393			3-269

#### PROGRAMMABLE FREQUENCY DIVIDERS/TIMERS

DESCRIPTION	FEATURES	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
			TABLE	PAGE	
Programmable Frequency Dividers/Digital Timers	Programming range $2^2$ to $2^{15}$	'HC294	IV	2-10	5-11
	Programming range $2^2$ to $2^{31}$	'HC292			5-11



## SYNCHRONOUS COUNTERS

DESCRIPTION	FEATURES	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
			TABLE	PAGE	
Decade	Async Clear	Synchronous Load	'HC160 'HC162	IV 2-10	3-115
	Sync Clear				3-115
Decade Counters with Output Registers	Sync Clear	Multiplexed 3-State Outputs	'HC692 'HC690	III 2-8	4-123
	Async Clear				4-123
Decade Up/Down	Clock Inhibit	Asynchronous Load	'HC190 'HC192	IV 2-10	3-149
	Async Clear				3-155
Decade Up/Down Counters with Output Registers	Sync Clear	Multiplexed 3-State Outputs	'HC698 'HC696	III 2-8	4-131
	Async Clear				4-131
Divide-by-8 Johnson Counter	Sync Clear		'HC4022 'HC7022	IV 2-10	4-143
Divide-by-10 Johnson Counter	Async Clear		'HC4017		4-147
4-Bit Binary	Async Clear Sync Clear	Synchronous Load	'HC161 'HC163		4-139
4-Bit Binary Counters with Output Registers	Sync Clear	Multiplexed 3-State Outputs	'HC693 'HC691	III 2-8	3-115
	Async Clear				3-115
4-Bit Binary Up/Down	Clock Inhibit	Asynchronous Load	'HC191 'HC193	IV 2-10	4-123
	Async Clear				4-123
4-Bit Binary Up/Down Counters with Output Registers	Sync Clear	Multiplexed 3-State Outputs	'HC699 'HC697	III 2-8	3-149
	Async Clear				3-155
8-Bit Binary with Input Registers	Sync Clear	Multiplexed 3-State I/O	'HC592 'HC593	IV 2-10	4-131
					4-131
8-Bit Binary with Output Registers	Sync Clear	3-State Outputs	'HC590	III 2-8	5-23
					5-23
					4-91

## MAGNITUDE COMPARATORS, PARITY GENERATORS/CHECKERS, AND PRIORITY ENCODERS

DESCRIPTION	FEATURES		DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
				TABLE	PAGE	
4-Bit Magnitude Comparators			'HC85	IV	2-10	4-7
8-Bit Magnitude Comparators	$\overline{P=Q}$ , $\overline{P>Q}$ Outputs	Enable Inputs	'HC682			4-115
			'HC684			4-115
	$\overline{P=Q}$ Outputs		'HC686			4-115
			'HC688			4-121
9-Bit Odd/Even Parity Generator/Checkers	Even, Odd Inputs		'HC180		3-147	
			'HC280		3-237	
8-/9-Bit Bus Transceivers with Parity Generator/Checkers	True Outputs	Enable and Direction Control	'HC659	III	2-8	3-353
			'HCT659	VII	2-14	3-361
	Inverting Outputs		'HC658	III	2-8	3-353
		'HCT658	VII	2-14	3-361	
	True Outputs	Independent Enables for A and B Buses	'HC665	III	2-8	3-367
			'HCT665	VII	2-14	3-375
	Inverting Outputs		'HC664	III	2-8	3-367
'HCT664		VII	2-14	3-375		
8-Line to 3-Line Priority Encoders	Enable Inputs and Outputs		'HC148	IV	2-10	3-93
10-Line Decimal to 4-Line BCD Priority Encoders			'HC147			3-93

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### ADDRESS COMPARATORS

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			TABLE	PAGE	
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	Latched Output	'HC678			4-103
12-Bit to 4-Bit Address Comparators	Output Enable	'HC679			4-109
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			TABLE	PAGE	
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	8 Functions	'HC381			5-17
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		TABLE	PAGE	
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32-Bit Parallel Error Detection and Correction	'HC632			5-41

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				TABLE	PAGE	
8-Line to 1-Line	Enable	Inverting	'HC152	III	2-8	3-103
		Complementary	'HC151			3-99
	Transparent Latches, Enable	Complementary 3-State	'HC251			3-215
			'HC354			4-43
			'HC356			4-47
Dual 4-Line to 1-Line	Independent Enables	True, 3-State	'HC253			3-219
		Inverting, 3-State	'HC353			3-247
		True	'HC153			3-107
		Inverting	'HC352			3-243
Quad 2-Line to 1-Line	Common Enable	True	'HC157			3-111
		Inverting	'HC158			3-111
		True, 3-State	'HC257			3-223
		Inverting, 3-State	'HC258			3-223
Quad 2-Line to 1-Line with Storage		True	'HC298	IV	2-10	3-239
Octal 2-Line to 1-Line	Input Registers	True, 3-State	'HC604	III	2-8	3-311

## DECODERS/DEMULPLEXERS

DESCRIPTION	FEATURES	OUTPUTS	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
				TABLE	PAGE	
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	Input Latches,	True	'HC4514			5-71
	Output Enable	Inverting	'HC4515			5-71
4-Line to 10-Line BCD-to-Decimal			'HC42			3-37
3-Line to 8-Line	3 Enables	True	'HC238	VIII	2-15	3-181
			'HCT238			3-185
		Inverting	'HC138	IV	2-10	3-83
			'HCT138	VIII	2-15	3-87
	3 Enables, Address Latches	True	'HC237	IV	2-10	3-173
			'HCT237	VIII	2-15	3-177
		Inverting	'HC137	IV	2-10	3-75
			'HCT137	VIII	2-15	3-79
Dual 2-Line to 4-Line	Independent Enables	Inverting	'HC139	IV	2-10	3-91
		True	'HC239			3-189

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DESCRIPTION	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
		TABLE	PAGE	
BCD-to-7-Segment Decoders/Drivers with Input Latches	'HC4511	IV	2-10	5-69

## ANALOG SWITCHES/MULTIPLEXERS/DEMULPLEXERS

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Dual 4-Channel Analog Multiplexer/Demultiplexer	'HC4052	—	—	5-65
Triple 2-Channel Analog Multiplexer/Demultiplexer	'HC4053	—	—	5-65

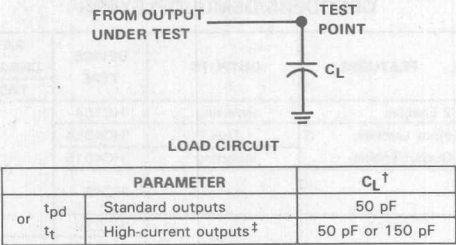
## RANDOM ACCESS MEMORIES

DESCRIPTION	ORGANIZATION	FEATURES	DEVICE TYPE	RATINGS AND CHARACTERISTICS		DESCRIPTIVE INFORMATION
				TABLE	PAGE	
64-Bit	16 × 4	3-State Inverting Outputs	'HC189	III	2-8	4-11
			'HCT189	VII	2-14	4-15
		3-State Noninverting Outputs	'HC219	III	2-8	4-11
			'HCT219	VII	2-14	4-15

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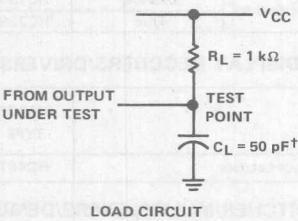
GENERAL INFORMATION

PARAMETER MEASUREMENT INFORMATION



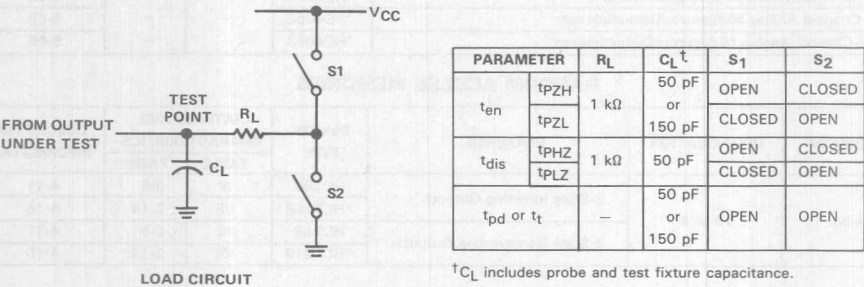
<sup>†</sup> $C_L$  includes probe and test fixture capacitance.  
<sup>‡</sup>High-current outputs are indicated by the  $\triangleright$  in the logic symbol.

FIGURE 1. TOTEM-POLE OUTPUTS



<sup>†</sup> $C_L$  includes probe and test fixture capacitance.

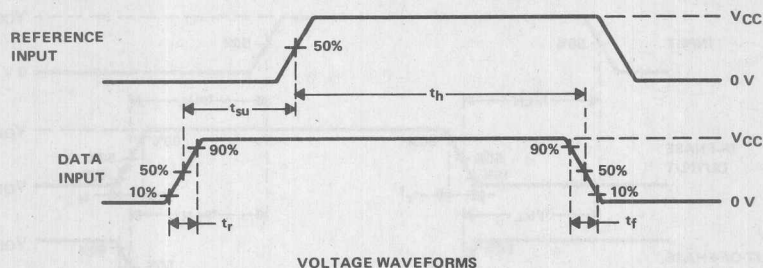
FIGURE 2. OPEN-DRAIN OUTPUTS



<sup>†</sup> $C_L$  includes probe and test fixture capacitance.

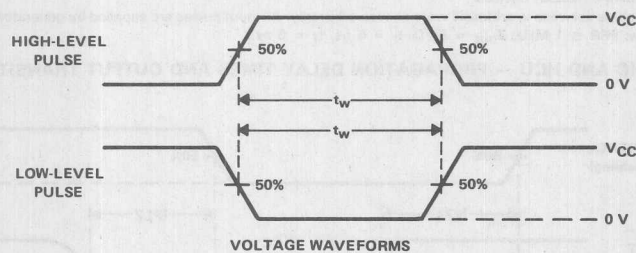
FIGURE 3. 3-STATE OUTPUTS

## PARAMETER MEASUREMENT INFORMATION



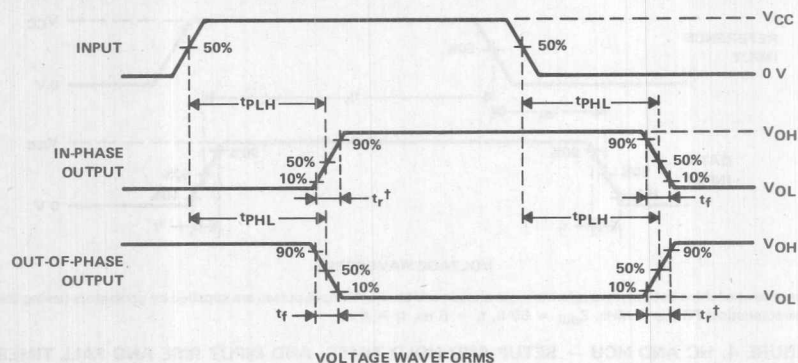
NOTE 1: Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .

FIGURE 4. HC AND HCU — SETUP AND HOLD TIMES, AND INPUT RISE AND FALL TIMES



NOTES: 1. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .  
2. For clock inputs,  $f_{max}$  is measured when the input duty cycle is 50%.

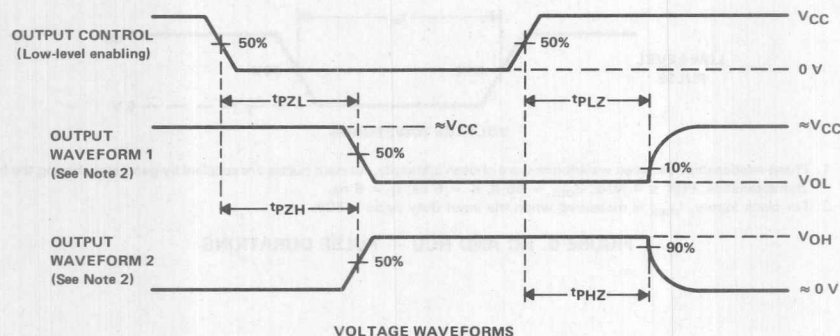
FIGURE 5. HC AND HCU — PULSE DURATIONS



$t_r^\dagger$  is not applicable to SN54/74HCU<sup>†</sup> devices.

NOTE 1: Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .

FIGURE 6. HC AND HCU — PROPAGATION DELAY TIMES AND OUTPUT TRANSITION TIMES



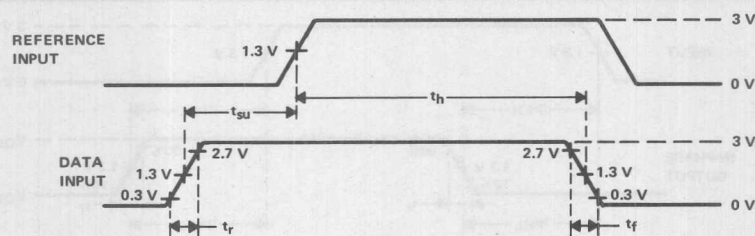
NOTES: 1. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq \text{MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .

2. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.

FIGURE 7. HC AND HCU — ENABLE AND DISABLE TIMES, 3-STATE OUTPUTS



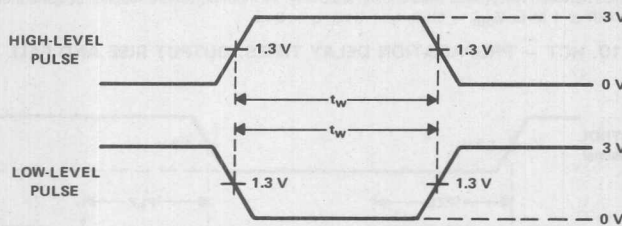
## PARAMETER MEASUREMENT INFORMATION



VOLTAGE WAVEFORMS

NOTE 1: Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .

FIGURE 8. HCT — SETUP AND HOLD TIMES, AND INPUT RISE AND FALL TIMES



VOLTAGE WAVEFORMS

NOTES: 1. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .  
2. For clock inputs,  $f_{max}$  is measured when the input duty cycle is 50%.

FIGURE 9. HCT — PULSE DURATIONS

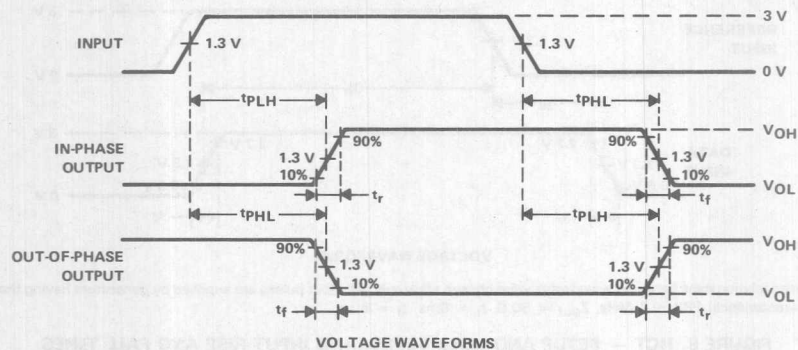
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GENERAL INFORMATION

## PARAMETER MEASUREMENT INFORMATION

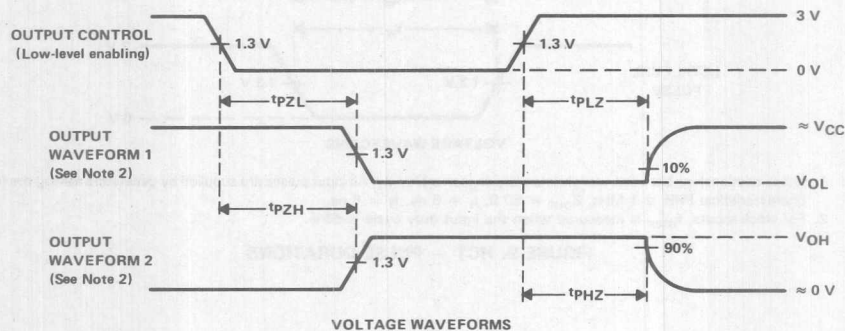
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GENERAL INFORMATION



NOTE 1: Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .

FIGURE 10. HCT — PROPAGATION DELAY TIMES, OUTPUT RISE AND FALL TIMES





NOTES: 1. Phase relationships between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1 \text{ MHz}$ ,  $Z_{out} \approx 50 \Omega$ ,  $t_r = 6 \text{ ns}$ ,  $t_f = 6 \text{ ns}$ .  
2. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.

FIGURE 11. HCT — ENABLE AND DISABLE TIMES FOR 3-STATE OUTPUTS





The following symbols are now being used in function tables on TI data sheets:

- H = high level (steady state)
- L = low level (steady state)
- $\uparrow$  = transition from low to high level
- $\downarrow$  = transition from high to low level
- X = irrelevant (any input, including transitions)
- Z = off (high-impedance) state of a 3-state output
- a...h = the level of steady-state inputs at inputs A through H, respectively
- $Q_0$  = level of Q before the indicated steady-state input conditions were established
- $\bar{Q}_0$  = complement of  $Q_0$  or level of  $\bar{Q}$  before the indicated steady-state input conditions were established
- $Q_n$  = level of Q before the most recent active transition indicated by  $\uparrow$  or  $\downarrow$
-  = one high-level pulse
-  = one low-level pulse

TOGGLE = each output changes to the complement of its previous level on each active transition indicated by  $\uparrow$  or  $\downarrow$ .

If, in the input columns, a row contains only the symbols H, L, and/or X, this means the indicated output is valid whenever the input configuration is achieved and regardless of the sequence in which it is achieved. The output persists so long as the input configuration is maintained.

If, in the input columns, a row contains H, L, and/or X together with  $\uparrow$  and/or  $\downarrow$ , this means the output is valid whenever the input configuration is achieved but the transition(s) must occur following the achievement of the steady-state levels. If the output is shown as a level (H, L,  $Q_0$ , or  $\bar{Q}_0$ ), it persists so long as the steady-state input levels and the levels that terminate indicated transitions are maintained. Unless otherwise indicated, input transitions in the opposite direction to those shown have no effect at the output. (If the output is shown as a pulse,  or , the pulse follows the indicated input transition and persists for an interval dependent on the circuit.)

## EXPLANATION OF FUNCTION TABLES

Among the most complex function tables in this book are those of the shift registers. These embody most of the symbols used in any of the function tables, plus more. Below is the function table of a 4-bit bidirectional universal shift register, e.g., type SN74HC194.

FUNCTION TABLE

INPUTS										OUTPUTS			
CLEAR	MODE		CLOCK	SERIAL		PARALLEL				Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>
	S1	S0		LEFT	RIGHT	A	B	C	D				
L	X	X	X	X	X	X	X	X	X	L	L	L	L
H	X	X	L	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>
H	H	H	↑	X	X	a	b	c	d	a	b	c	d
H	L	H	↑	X	H	X	X	X	X	H	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>
H	L	H	↑	X	L	X	X	X	X	L	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>
H	H	L	↑	H	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	H
H	H	L	↑	L	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	L
H	L	L	X	X	X	X	X	X	X	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>D0</sub>

The first line of the table represents a synchronous clearing of the register and says that if clear is low, all four outputs will be reset low regardless of the other inputs. In the following lines, clear is inactive (high) and so has no effect.

The second line shows that so long as the clock input remains low (while clear is high), no other input has any effect and the outputs maintain the levels they assumed before the steady-state combination of clear high and clock low was established. Since on other lines of the table only the rising transition of the clock is shown to be active, the second line implicitly shows that no further change in the outputs will occur while the clock remains high or on the high-to-low transition of the clock.

The third line of the table represents synchronous parallel loading of the register and says that if S1 and S0 are both high then, without regard to the serial input, the data entered at A will be at output Q<sub>A</sub>, data entered at B will be at Q<sub>B</sub>, and so forth, following a low-to-high clock transition.

The fourth and fifth lines represent the loading of high- and low-level data, respectively, from the shift-right serial input and the shifting of previously entered data one bit; data previously at Q<sub>A</sub> is now at Q<sub>B</sub>, the previous levels of Q<sub>B</sub> and Q<sub>C</sub> are now at Q<sub>C</sub> and Q<sub>D</sub> respectively, and the data previously at Q<sub>D</sub> is no longer in the register. This entry of serial data and shift takes place on the low-to-high transition of the clock when S1 is low and S0 is high and the levels at inputs A through D have no effect.

The sixth and seventh lines represent the loading of high- and low-level data, respectively, from the shift-left serial input and the shifting of previously entered data one bit; data previously at Q<sub>B</sub> is now at Q<sub>A</sub>, the previous levels of Q<sub>C</sub> and Q<sub>D</sub> are now at Q<sub>B</sub> and Q<sub>C</sub>, respectively, and the data previously at Q<sub>A</sub> is no longer in the register. This entry of serial data and shift takes place on the low-to-high transition of the clock when S1 is high and S0 is low and the levels at inputs A through D have no effect.

The last line shows that as long as both mode inputs are low, no other input has any effect and, as in the second line, the outputs maintain the levels they assumed before the steady-state combination of clear high and both mode inputs low was established.

## INTRODUCTION

These symbols, terms, and definitions are in accordance with those currently agreed upon by the JEDEC Council of the Electronic Industries Association (EIA) for use in the USA and by the International Electrotechnical Commission (IEC) for international use.

## OPERATING CONDITIONS AND CHARACTERISTICS (IN SEQUENCE BY LETTER SYMBOLS)

- C<sub>pd</sub>** **Power dissipation capacitance**  
Used to determine the no-load dynamic power dissipation per logic function (see individual circuit pages):  $P_D = C_{pd} V_{CC}^2 f + I_{CC} V_{CC}$ .
- f<sub>max</sub>** **Maximum clock frequency**  
The highest rate at which the clock input of a bistable circuit can be driven through its required sequence while maintaining stable transitions of logic level at the output with input conditions established that should cause changes of output logic level in accordance with the specification.
- I<sub>CC</sub>** **Supply current**  
The current into\* the V<sub>CC</sub> supply terminal of an integrated circuit.
- I<sub>IH</sub>** **High-level input current**  
The current into\* an input when a high-level voltage is applied to that input.
- I<sub>IL</sub>** **Low-level input current**  
The current into\* an input when a low-level voltage is applied to that input.
- I<sub>OH</sub>** **High-level output current**  
The current into\* an output with input conditions applied that, according to the product specification, will establish a high level at the output.
- I<sub>OL</sub>** **Low-level output current**  
The current into\* an output with input conditions applied that, according to the product specification, will establish a low level at the output.
- I<sub>OZ</sub>** **Off-state (high-impedance-state) output current (of a three-state output)**  
The current flowing into\* an output having three-state capability with input conditions established that, according to the production specification, will establish the high-impedance state at the output.
- V<sub>IH</sub>** **High-level input voltage**  
An input voltage within the more positive (less negative) of the two ranges of values used to represent the binary variables.  
NOTE: A minimum is specified that is the least-positive value of high-level input voltage for which operation of the logic element within specification limits is guaranteed.
- V<sub>IL</sub>** **Low-level input voltage**  
An input voltage level within the less positive (more negative) of the two ranges of values used to represent the binary variables.  
NOTE: A minimum is specified that is the most-positive value of low-level input voltage for which operation of the logic element within specification limits is guaranteed.

\*Current out of a terminal is given as a negative value.

## GLOSSARY SYMBOLS, TERMS, AND DEFINITIONS

### 1

#### GENERAL INFORMATION

**VOH High-level output voltage**

The voltage at an output terminal with input conditions applied that, according to product specification, will establish a high level at the output.

**VOL Low-level output voltage**

The voltage at an output terminal with input conditions applied that, according to product specification, will establish a low level at the output.

**VT+ Positive-going threshold level**

The voltage level at a transition-operated input that causes operation of the logic element according to specification as the input voltage rises from a level below the negative-going threshold voltage, VT-.

**VT- Negative-going threshold level**

The voltage level at a transition-operated input that causes operation of the logic element according to specification as the input voltage falls from a level above the positive-going threshold voltage, VT+.

**ta Access time**

The time interval between the application of a specified input pulse and the availability of valid signals at an output.

**tdis Disable time (of a three-state output)**

The time interval between the specified reference points on the input and output voltage waveforms, with the three-state output changing from either of the defined active levels (high or low) to a high-impedance (off) state. (tdis = tPHZ or tPLZ).

**ten Enable time (of a three-state output)**

The time interval between the specified reference points on the input and output voltage waveforms, with the three-state output changing from a high-impedance (off) state to either of the defined active levels (high or low). (ten = tPZH or tPZL).

**tf Fall time**

The time interval between two reference points (90% and 10% unless otherwise specified) on a waveform that is changing from the defined high level to the defined low level.

**th Hold time**

The time interval during which a signal is retained at a specified input terminal after an active transition occurs at another specified input terminal.

NOTES: 1. The hold time is the actual time interval between two signal events and is determined by the system in which the digital circuit operates. A minimum value is specified that is the shortest interval for which correct operation of the digital circuit is guaranteed.

2. The hold time may have a negative value in which case the minimum limit defines the longest interval (between the release of the signal and the active transition) for which correct operation of the digital circuit is guaranteed.

**t<sub>pd</sub> Propagation delay time**

The time between the specified reference points on the input and output voltage waveforms with the output changing from one defined level (high or low) to the other defined level. (t<sub>pd</sub> = t<sub>PHL</sub> or t<sub>PLH</sub>).

- tPHL Propagation delay time, high-to-low level output**  
The time between the specified reference points on the input and output voltage waveforms with the output changing from the defined high level to the defined low level.
- tPHZ Disable time (of a three-state output) from high level**  
The time interval between the specified reference points on the input and the output voltage waveforms with the three-state output changing from the defined high level to a high-impedance (off) state.
- tPLH Propagation delay time, low-to-high-level output**  
The time between the specified reference points on the input and output voltage waveforms with the output changing from the defined low level to the defined high level.
- tPLZ Disable time (of a three-state output) from low level**  
The time interval between the specified reference points on the input and output voltage waveforms with the three-state output changing from the defined low level to a high-impedance (off) state.
- tpZH Enable time (of a three-state output) to high level**  
The time interval between the specified reference points on the input and output voltage waveforms with the three-state output changing from a high-impedance (off) state to the defined high level.
- tpZL Enable time (of a three-state output) to low level**  
The time interval between the specified reference points on the input and output voltage waveforms with the three-state output changing from a high-impedance (off) state to the defined low level.
- t<sub>r</sub> Rise time**  
The time interval between two reference points (10% and 90% unless otherwise specified) on a waveform that is changing from the defined low level to the defined high level.
- t<sub>sr</sub> Sense recovery time**  
The time interval needed to switch a memory from a write mode to a read mode and to obtain valid data signals at the output.
- t<sub>su</sub> Setup time**  
The time interval between the application of a signal at a specified input terminal and a subsequent active transition at another specified input terminal.  
NOTES: 1. The setup time is the actual time interval between two signal events and is determined by the system in which the digital circuit operates. A minimum value is specified that is the shortest interval for which correct operation of the digital circuit is guaranteed.  
2. The setup time may have a negative value in which case the minimum limit defines the longest interval (between the active transition and the application of the other signal) for which correct operation of the digital circuit is guaranteed.
- t<sub>t</sub> Transition time (general)**  
The time interval between two reference points (10% and 90% unless otherwise specified) on a waveform that is changing from the defined low level to the defined high level (rise time) or from the defined high level to the defined low level (fall time).
- t<sub>w</sub> Pulse duration (width)**  
The time interval between specified reference points on the leading and trailing edges of the pulse waveform.





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## 2

## RATINGS AND CHARACTERISTICS





These devices contain circuits to protect the inputs and outputs against damage due to high static voltages or electrostatic fields, however, it is advised that precautions be taken to avoid application of any voltage higher than maximum-rated voltages to these high-impedance circuits.

Unused inputs must always be connected to an appropriate logic voltage level, preferably either  $V_{CC}$  or ground.

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RATINGS AND CHARACTERISTICS

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D2804, DECEMBER 1982—REVISED MARCH 1984

absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±25 mA
Continuous current through $V_{CC}$ or GND pins	±50 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300 °C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260 °C
Storage temperature range	−65 °C to 150 °C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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RATINGS AND CHARACTERISTICS

recommended operating conditions

			SN54HC*			SN74HC*			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V <sub>CC</sub>	Supply voltage		2	5	6	2	5	6	V
V <sub>IH</sub>	High-level input voltage	V <sub>CC</sub> = 2 V	1.5			1.5			V
		V <sub>CC</sub> = 4.5 V	3.15			3.15			
		V <sub>CC</sub> = 6 V	4.2			4.2			
V <sub>IL</sub>	Low-level input voltage	V <sub>CC</sub> = 2 V	0			0			V
		V <sub>CC</sub> = 4.5 V	0			0			
		V <sub>CC</sub> = 6 V	0			0			
V <sub>I</sub>	Input voltage		0			V <sub>CC</sub>			V
V <sub>O</sub>	Output voltage		0			V <sub>CC</sub>			V
t <sub>t</sub>	Input transition (rise and fall) times (except Schmitt-trigger inputs)	V <sub>CC</sub> = 2 V	0			1000			ns
		V <sub>CC</sub> = 4.5 V	0			500			
		V <sub>CC</sub> = 6 V	0			400			
T <sub>A</sub>	Operating free-air temperature		−55			125			°C

**TABLE I**  
**SPECIFICATIONS FOR HC SSI CIRCUITS**

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC'		SN74HC'		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub> (Totem-pole outputs)	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -20 µA	2 V	1.9	1.998		1.9		1.9		V
		4.5 V	4.4	4.499		4.4		4.4		
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -4 mA	6 V	5.9	5.999		5.9		5.9		
		4.5 V	3.98	4.30		3.7		3.84		
I <sub>OH</sub> (Open-drain outputs)	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , V <sub>O</sub> = V <sub>CC</sub>	6 V	5.48	5.80		5.2		5.34		µA
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 µA	2 V								
		4.5 V								
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 µA	6 V								V
		4.5 V								
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 4 mA	6 V								
		4.5 V								
V <sub>T+</sub> †	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 5.2 mA	6 V								V
		4.5 V								
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 µA	2 V	0.8	1.2	1.5					
		4.5 V	2	2.5	3.15					
V <sub>T-</sub> †	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 4 mA	6 V	2.5	3.3	4.2					V
		4.5 V	0.3	0.6	0.8					
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 5.2 mA	6 V	0.9	1.6	2					
		4.5 V	1.2	2	2.5					
V <sub>T+</sub> - V <sub>T-</sub> †	V <sub>I</sub> = 0 to V <sub>CC</sub>	2 V	0.2	0.6	1					V
		4.5 V	0.4	0.9	1.4					
	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	6 V	0.5	1.3	1.7					
		4.5 V								
I <sub>I</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub>	6 V	±0.1 ±100			±1000		±1000		nA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	6 V	2			40		20		µA
C <sub>I</sub>		2 to 6 V	3 10			10		10		pF

† This parameter applies only for Schmitt-trigger inputs.

#### switching characteristics

See individual circuit pages.

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RATINGS AND CHARACTERISTICS

## absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±25 mA
Continuous current through $V_{CC}$ or GND pins	±50 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	−65°C to 150°C

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† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## recommended operating conditions

			SN54HC*			SN74HC*			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage		2	5	6	2	5	6	V
$V_{IH}$	High-level input voltage	$V_{CC} = 2 \text{ V}$	1.5			1.5			V
		$V_{CC} = 4.5 \text{ V}$	3.15			3.15			
		$V_{CC} = 6 \text{ V}$	4.2			4.2			
$V_{IL}$	Low-level input voltage	$V_{CC} = 2 \text{ V}$	0		0.3	0		0.3	V
		$V_{CC} = 4.5 \text{ V}$	0		0.9	0		0.9	
		$V_{CC} = 6 \text{ V}$	0		1.2	0		1.2	
$V_I$	Input voltage		0		$V_{CC}$	0		$V_{CC}$	V
$V_O$	Output voltage		0		$V_{CC}$	0		$V_{CC}$	V
$t_t$	Input transition (rise and fall) times	$V_{CC} = 2 \text{ V}$	0		1000	0		1000	ns
		$V_{CC} = 4.5 \text{ V}$	0		500	0		500	
		$V_{CC} = 6 \text{ V}$	0		400	0		400	
$T_A$	Operating free-air temperature		−55		125	−40		85	°C

See individual circuits for additional timing requirements.

TABLE II  
SPECIFICATIONS FOR HC DUAL AND QUAD FLIP-FLOPS AND LATCHES

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC'		SN74HC'		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -20 μA	2 V	1.9	1.998		1.9		1.9		V
		4.5 V	4.4	4.499		4.4		4.4		
		6 V	5.9	5.999		5.9		5.9		
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -4 mA	4.5 V	3.98	4.30		3.7		3.84		
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 μA	2 V		0.002	0.1		0.1		0.1	V
		4.5 V		0.001	0.1		0.1		0.1	
		6 V		0.001	0.1		0.1		0.1	
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 4 mA	4.5 V		0.17	0.26		0.4		0.33	
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 5.2 mA	6 V		0.15	0.26		0.4		0.33	
I <sub>I</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub>	6 V	± 0.1 ± 100			± 1000		± 1000		nA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	6 V	4			80		40		μA
C <sub>I</sub>		2 to 6 V	3 10			10		10		pF

#### switching characteristics

See individual circuit pages.

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RATINGS AND CHARACTERISTICS

absolute maximum ratings over operating free-air temperature range<sup>†</sup>

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±35 mA
Continuous current through $V_{CC}$ or GND pins	±70 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	−65°C to 150°C

<sup>†</sup> Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

recommended operating conditions

			SN54HC <sup>1</sup>			SN74HC <sup>1</sup>			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage		2	5	6	2	5	6	V
$V_{IH}$	High-level input voltage	$V_{CC} = 2 \text{ V}$	1.5			1.5			V
		$V_{CC} = 4.5 \text{ V}$	3.15			3.15			
		$V_{CC} = 6 \text{ V}$	4.2			4.2			
$V_{IL}$	Low-level input voltage	$V_{CC} = 2 \text{ V}$	0		0.3	0		0.3	V
		$V_{CC} = 4.5 \text{ V}$	0		0.9	0		0.9	
		$V_{CC} = 6 \text{ V}$	0		1.2	0		1.2	
$V_I$	Input voltage		0		$V_{CC}$	0		$V_{CC}$	V
$V_O$	Output voltage		0		$V_{CC}$	0		$V_{CC}$	V
$t_t$	Input transition (rise and fall) times (except Schmitt-trigger inputs)	$V_{CC} = 2 \text{ V}$	0		1000	0		1000	ns
		$V_{CC} = 4.5 \text{ V}$	0		500	0		500	
		$V_{CC} = 6 \text{ V}$	0		400	0		400	
$T_A$	Operating free-air temperature		−55		125	−40		85	°C

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RATINGS AND CHARACTERISTICS



TABLE III  
SPECIFICATIONS FOR HC CIRCUITS WITH HIGH-CURRENT OUTPUTS

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC <sup>*</sup>		SN74HC <sup>*</sup>		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -20 μA	2 V	1.9	1.998		1.9		1.9		V
		4.5 V	4.4	4.499		4.4		4.4		
		6 V	5.9	5.999		5.9		5.9		
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = See Notes 1 and 5	4.5 V	3.98	4.30		3.7		3.84		
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 μA	2 V		0.002	0.1		0.1		0.1	V
		4.5 V		0.001	0.1		0.1		0.1	
		6 V		0.001	0.1		0.1		0.1	
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , V <sub>OL</sub> = See Notes 3 and 5	4.5 V		0.17	0.26		0.4		0.33	
I <sub>I</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub> <sup>*</sup>	6 V		±0.1	±100		±1000		±1000	nA
		6 V		±0.01	±0.5		±10		±5	μA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	6 V			8		160		80	μA
C <sub>I</sub> <sup>‡</sup>		2 to 6 V		3	10		10		10	pF

\* This parameter does not apply to transceiver I/O pins. Instead use I<sub>OZ</sub> (V<sub>I/O</sub> = 0 to V<sub>CC</sub>).

† This parameter, I<sub>OZ</sub>, the high-impedance-state output current, applies only to three-state outputs and transceiver I/O pins.

‡ This parameter, C<sub>I</sub>, does not apply to transceiver I/O ports.

- NOTES: 1. I<sub>OH</sub> = -4 mA for standard outputs and -6 mA for high-current outputs.  
2. I<sub>OH</sub> = -5.2 mA for standard outputs and -7.8 mA for high-current outputs.  
3. I<sub>OL</sub> = 4 mA for standard outputs and 6 mA for high-current outputs.  
4. I<sub>OL</sub> = 5.2 mA for standard outputs and 7.8 mA for high-current outputs.  
5. High-current outputs are indicated by the ▸ in the logic symbol. All 3-state outputs (indicated by the ▽ in the logic symbol) are also high-current outputs.

## switching characteristics

See individual circuit pages.

2

RATINGS AND CHARACTERISTICS

D2804, DECEMBER 1982—REVISED MARCH 1984

absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±25 mA
Continuous current through $V_{CC}$ or GND pins	±50 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	−65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

recommended operating conditions

		SN54HC'			SN74HC'			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage	2	5	6	2	5	6	V
$V_{IH}$	High-level input voltage	$V_{CC} = 2 \text{ V}$		1.5	$V_{CC} = 2 \text{ V}$		1.5	V
		$V_{CC} = 4.5 \text{ V}$		3.15	$V_{CC} = 4.5 \text{ V}$		3.15	
		$V_{CC} = 6 \text{ V}$		4.2	$V_{CC} = 6 \text{ V}$		4.2	
$V_{IL}$	Low-level input voltage	$V_{CC} = 2 \text{ V}$		0	$V_{CC} = 2 \text{ V}$		0	V
		$V_{CC} = 4.5 \text{ V}$		0	$V_{CC} = 4.5 \text{ V}$		0	
		$V_{CC} = 6 \text{ V}$		0	$V_{CC} = 6 \text{ V}$		0	
$V_I$	Input voltage	0	$V_{CC}$		0	$V_{CC}$		V
$V_O$	Output voltage	0	$V_{CC}$		0	$V_{CC}$		V
$t_t$	Input transition (rise and fall) times (except Schmitt-trigger inputs)	$V_{CC} = 2 \text{ V}$		0	$V_{CC} = 2 \text{ V}$		1000	ns
		$V_{CC} = 4.5 \text{ V}$		0	$V_{CC} = 4.5 \text{ V}$		500	
		$V_{CC} = 6 \text{ V}$		0	$V_{CC} = 6 \text{ V}$		400	
$T_A$	Operating free-air temperature	−55	125		−40	85		°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC <sup>1</sup>		SN74HC <sup>1</sup>		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -20 µA	2 V	1.9	1.998		1.9		1.9		V
		4.5 V	4.4	4.499		4.4		4.4		
		6 V	5.9	5.999		5.9		5.9		
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -4 mA	4.5 V	3.98	4.30		3.7		3.84		
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = -5.2 mA	6 V	5.48	5.80		5.2		5.34		V
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 µA	2 V		0.002	0.1		0.1		0.1	
		4.5 V		0.001	0.1		0.1		0.1	
		6 V		0.001	0.1		0.1		0.1	
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 4 mA	4.5 V		0.17	0.26		0.4		0.33	
I <sub>I</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 5.2 mA	6 V		0.15	0.26		0.4		0.33	nA
	V <sub>I</sub> = 0 to V <sub>CC</sub>	6 V		±0.1	±100		±1000		±1000	
I <sub>S(off)</sub> <sup>†</sup>	V <sub>I</sub> = V <sub>CC</sub> or 0, V <sub>S</sub> = ±V <sub>CC</sub>	6 V			±0.1		±1		±1	µA
V <sub>T+</sub> <sup>‡</sup>		2 V	0.8	1.2	1.5					V
		4.5 V		2	2.5					
		6 V		2.5	3.3					
V <sub>T-</sub> <sup>‡</sup>		2 V	0.3	0.6	0.8					V
		4.5 V		0.9	1.6					
		6 V		1.2	2					
V <sub>T+</sub> - V <sub>T-</sub> <sup>‡</sup>		2 V		0.2	0.6					V
		4.5 V		0.4	0.9					
		6 V		0.5	1.3					
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	6 V			8		160		80	µA
C <sub>I</sub>		2 to 6 V		3	10		10		10	pF

<sup>†</sup>This parameter, I<sub>S(off)</sub>, is for analog switches only.

<sup>‡</sup>These threshold parameters apply only to Schmitt-trigger inputs.

## switching characteristics

See individual circuit pages.

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RATINGS AND CHARACTERISTICS

D2804, MARCH 1984

absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	-0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±25 mA
Continuous current through $V_{CC}$ or GND pins	±50 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	-65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

recommended operating conditions

		SN54HCT <sup>†</sup>			SN74HCT <sup>†</sup>			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage	4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$			2			V
$V_{IL}$	Low-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$			0			V
$V_I$	Input voltage	0			$V_{CC}$			V
$V_O$	Output voltage	0			$V_{CC}$			V
$t_t$	Input transition (rise and fall) times	0			500			ns
$T_A$	Operating free-air temperature	-55			-40			°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT <sup>†</sup>		SN74HCT <sup>†</sup>		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$V_{OH}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -20 \mu\text{A}$	4.5 V	4.4	4.499		4.4		4.4		V
	$V_I = V_{IL}, I_{OH} = -4 \text{ mA}$	4.5 V	3.98	4.30		3.7		3.84		
$V_{OL}$	$V_I \text{ or } V_{IL}, I_{OL} = 20 \mu\text{A}$	4.5 V		0.001	0.1		0.1		0.1	V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 4 \text{ mA}$	4.5 V		0.17	0.26		0.4		0.33	
$I_I$	$V_I = 0 \text{ to } V_{CC}$	5.5 V	±0.1 ±100			±1000		±1000		nA
$I_{CC}$	$V_I = V_{CC} \text{ or } 0, I_O = 0$	5.5 V	2			40		20		μA
$\Delta I_{CC}^\ddagger$	One input at 0.5 V or 2.4 V, Other inputs at 0 V or $V_{CC}$	5.5 V	1.4 2.4			2.9		3		mA
$C_I$		4.5 to 5.5 V	3 10			10		10		pF

† This is the increase in supply current for each input that is at one of the specified TTL voltage levels rather than 0 V or  $V_{CC}$ .

switching characteristics

See individual circuit pages.

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RATINGS AND CHARACTERISTICS

absolute maximum ratings over operating free-air temperature range<sup>†</sup>

Supply voltage range, $V_{CC}$	-0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	$\pm 20$ mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	$\pm 20$ mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	$\pm 25$ mA
Continuous current through $V_{CC}$ or GND pins	$\pm 50$ mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	-65°C to 150°C

<sup>†</sup> Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## recommended operating conditions

		SN54HCT <sup>†</sup>			SN74HCT <sup>†</sup>			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage	4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$			2			V
$V_{IL}$	Low-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$			0			V
$V_I$	Input voltage	0		$V_{CC}$	0		$V_{CC}$	V
$V_O$	Output voltage	0		$V_{CC}$	0		$V_{CC}$	V
$t_t$	Input transition (rise and fall) times	0		500	0		500	ns
$T_A$	Operating free-air temperature	-55		125	-40		85	°C

## electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT <sup>†</sup>		SN74HCT <sup>†</sup>		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$V_{OH}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -20 \mu\text{A}$	4.5 V	4.4	4.499		4.4		4.4		V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -4 \text{ mA}$	4.5 V	3.98	4.30		3.7		3.84		
$V_{OL}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = 20 \mu\text{A}$	4.5 V		0.001	0.1		0.1		0.1	V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 4 \text{ mA}$	4.5 V		0.17	0.26		0.4		0.33	
$I_I$	$V_I = 0 \text{ to } V_{CC}$	5.5 V	$\pm 0.1 \pm 100$			$\pm 1000$		$\pm 1000$		nA
$I_{CC}$	$V_I = V_{CC} \text{ or } 0, I_O = 0$	5.5 V	4			80		40		$\mu\text{A}$
$\Delta I_{CC}^\ddagger$	One input at 0.5 V or 2.4 V, Other inputs at 0 V or $V_{CC}$	5.5 V	1.4 2.4			2.9		3		mA
$C_I$		4.5 to 5.5 V	3 10			10		10		pF

<sup>†</sup> This is the increase in supply current for each input that is at one of the specified TTL voltage levels rather than 0 V or  $V_{CC}$ .

## switching characteristics

See individual circuit pages.

absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±35 mA
Continuous current through $V_{CC}$ or GND pins	±70 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300 °C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260 °C
Storage temperature range	−65 °C to 150 °C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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RATINGS AND CHARACTERISTICS

recommended operating conditions

			SN54HCT*			SN74HCT*			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage		4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$	2			2			V
$V_{IL}$	Low-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$	0		0.8	0		0.8	V
$V_I$	Input voltage		0		$V_{CC}$	0		$V_{CC}$	V
$V_O$	Output voltage		0		$V_{CC}$	0		$V_{CC}$	V
$t_t$	Input transition (rise and fall) times		0		500	0		500	ns
$T_A$	Operating free-air temperature		−55		125	−40		85	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT*		SN74HCT*		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$V_{OH}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -20 \mu\text{A}$	4.5 V	4.4	4.499		4.4		4.4		V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = \text{See Notes 1 and 3}$	4.5 V	3.98	4.30		3.7		3.84		
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = 20 \mu\text{A}$	4.5 V		0.001	0.1		0.1		0.1	
$V_{OL}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 20 \mu\text{A}$	4.5 V					0.4		0.33	V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = \text{See Notes 2 and 3}$	4.5 V		0.17	0.26					
	$V_I = 0 \text{ to } V_{CC}^*$	5.5 V		±0.1	±100		±1000		±1000	
$I_{OZ}^\dagger$	$V_O = V_{CC} \text{ or } 0, V_I = V_{IH} \text{ or } V_{IL}$	5.5 V		±0.01	±0.5		±10		±5	μA
$I_{CC}$	$V_I = V_{CC} \text{ or } 0, I_O = 0$	5.5 V			8		160		80	μA
$\Delta I_{CC}^\S$	One input at 0.5 V or 2.4 V Other inputs at 0 V or $V_{CC}$	5.5 V		1.4	2.4		2.9		3	mA
$C_I^\ddagger$		4.5 to 5.5 V		3	10		10		10	pF

\* This parameter does not apply to transceiver I/O pins. Instead use  $I_{OZ} (V_{IO} = 0 \text{ to } V_{CC})$ .

† This parameter,  $I_{OZ}$ , the high impedance-state output current, applies only for three-state outputs and transceiver I/O pins.

§ This is the increase in supply current for each input that is at one of the specified TTL voltage levels rather than 0 V or  $V_{CC}$ .

‡ This parameter,  $C_I$ , does not apply to transceiver I/O ports.

NOTES: 1.  $I_{OH} = -4 \text{ mA}$  for standard outputs and  $-6 \text{ mA}$  for high-current outputs.

2.  $I_{OL} = 4 \text{ mA}$  for standard outputs and  $6 \text{ mA}$  for high-current outputs.

3. High-current outputs are indicated by the  $\triangleright$  in the logic symbol. All 3-state outputs (indicated by the  $\nabla$  in the logic symbol) are also high-current outputs.

switching characteristics

See individual circuit pages.



D2804, MARCH 1984

## absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	−0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	±20 mA
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	±20 mA
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	±25 mA
Continuous current through $V_{CC}$ or GND pins	±50 mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range	−65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## recommended operating conditions

			SN54HCT'			SN74HCT'			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage		4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$	2			2			V
$V_{IL}$	Low-level input voltage	$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$	0	0.8		0	0.8		V
$V_I$	Input voltage		0	$V_{CC}$		0	$V_{CC}$		V
$V_O$	Output voltage		0	$V_{CC}$		0	$V_{CC}$		V
$t_t$	Input transition (rise and fall) times		0	500		0	500		ns
$T_A$	Operating free-air temperature		−55	125		−40	85		°C

## electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT'		SN74HCT'		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$V_{OH}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -20 \mu\text{A}$	4.5 V	4.4	4.499		4.4		4.4		V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -4 \text{ mA}$	4.5 V	3.98	4.30		3.7		3.84		
$V_{OL}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = 20 \mu\text{A}$	4.5 V		0.001	0.1		0.1		0.1	V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 4 \text{ mA}$	4.5 V		0.17	0.26		0.4		0.33	
$I_I$	$V_I = 0 \text{ to } V_{CC}$	5.5 V	±0.1 ±100			±1000		±1000		nA
$I_{S(off)}^\dagger$	$V_I = V_{IH} \text{ or } V_{IL}, V_S = \pm V_{CC}$	5.5 V	±0.1			±1		±1		μA
$I_{CC}$	$V_I = V_{CC} \text{ or } 0, I_O = 0$	5.5 V	8			160		80		μA
$\Delta I_{CC}^\S$	One input at 0.5 V or 2.4 V, Other inputs at 0 V or $V_{CC}$	5.5 V	1.4 2.4			2.9		3		mA
$C_I$		4.5 to 5.5 V	3 10			10		10		pF

† This parameter,  $I_{S(off)}$ , is for analog switches only.

§ This is the increase in supply current for each input that is at one of the specified TTL voltage levels rather than 0 V or  $V_{CC}$ .

## switching characteristics

See individual circuit pages.

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RATINGS AND CHARACTERISTICS

D2804, MARCH 1984

## absolute maximum ratings over operating free-air temperature range†

Supply voltage range, $V_{CC}$	-0.5 V to 7 V
Input diode current, $I_{IK}(V_I < 0 \text{ or } V_I > V_{CC})$	$\pm 20 \text{ mA}$
Output diode current, $I_{OK}(V_O < 0 \text{ or } V_O > V_{CC})$	$\pm 20 \text{ mA}$
Continuous output current, $I_O (V_O = 0 \text{ to } V_{CC})$	$\pm 25 \text{ mA}$
Continuous current through $V_{CC}$ or GND pins	$\pm 50 \text{ mA}$
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: FH, FK, or J package	$300^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	$260^\circ\text{C}$
Storage temperature range	$-65^\circ\text{C}$ to $150^\circ\text{C}$

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## recommended operating conditions

			SN54HCU'			SN74HCU'			UNIT		
			MIN	NOM	MAX	MIN	NOM	MAX			
V <sub>CC</sub>	Supply voltage		2	5	6	2	5	6	V		
V <sub>IH</sub>	High-level input voltage	V <sub>CC</sub> = 2 V	1.7			1.7			V		
		V <sub>CC</sub> = 4.5 V	3.6			3.6					
		V <sub>CC</sub> = 6 V	4.8			4.8					
V <sub>IL</sub>	Low-level input voltage	V <sub>CC</sub> = 2 V	0			0			V		
		V <sub>CC</sub> = 4.5 V	0			0					
		V <sub>CC</sub> = 6 V	0			0					
V <sub>I</sub>	Input voltage		0			V <sub>CC</sub>			V		
V <sub>O</sub>	Output voltage		0			V <sub>CC</sub>			V		
t <sub>t</sub>	Input transition (rise and fall) times	V <sub>CC</sub> = 2 V	0			1000			ns		
		V <sub>CC</sub> = 4.5 V	0			500					
		V <sub>CC</sub> = 6 V	0			400					
T <sub>A</sub>	Operating free-air temperature		-55			125			-40	85	°C

## electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCU'		SN74HCU'		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$V_{OH}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -20 \mu\text{A}$	2 V	1.8			1.8		1.8		V
		4.5 V	4			4		4		
		6 V	5.5			5.5		5.5		
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -4 \text{ mA}$	4.5 V	3.98			3.7		3.84		
$V_{OL}$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OH} = -5.2 \text{ mA}$	6 V	5.48			5.2		5.34		V
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 20 \mu\text{A}$	2 V		0.2		0.2		0.2		
		4.5 V		0.5		0.5		0.5		
		6 V		0.5		0.5		0.5		
	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 4 \text{ mA}$	4.5 V		0.26		0.4		0.33		
$I_I$	$V_I = V_{IH} \text{ or } V_{IL}, I_{OL} = 5.2 \text{ mA}$	6 V		0.26		0.4		0.33		nA
	$V_I = 0 \text{ to } V_{CC}$	6 V		$\pm 100$		$\pm 1000$		$\pm 1000$		
$I_{CC}$	$V_I = V_{CC} \text{ or } 0, I_O = 0$	6 V		2		40		20		$\mu\text{A}$
$C_I$		2 to 6 V		3	10		10		10	pF

## switching characteristics

See individual circuit pages.

2

RATINGS AND CHARACTERISTICS

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**GENERAL INFORMATION**

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**RATINGS AND CHARACTERISTICS**

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**HCMOS DEVICES — ADVANCE INFORMATION**

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**ATTENTION**

These devices contain circuits to protect the inputs and outputs against damage due to high static voltages or electrostatic fields, however, it is advised that precautions be taken to avoid application of any voltage higher than maximum-rated voltages to these high-impedance circuits.

Unused inputs must always be connected to an appropriate logic voltage level, preferably either  $V_{CC}$  or ground.

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC00, SN74HC00 QUADRUPLE 2-INPUT POSITIVE-NAND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

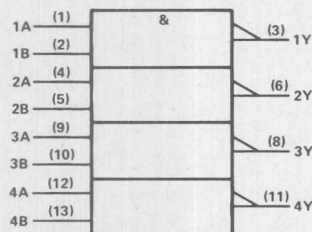
These devices contain four independent 2-input NAND gates. They perform the Boolean functions  $Y = \overline{A \cdot B}$  or  $Y = \overline{A + B}$  in positive logic.

The SN54HC00 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC00 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

### logic symbol

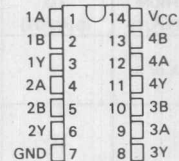


Pin numbers shown are for J and N packages.

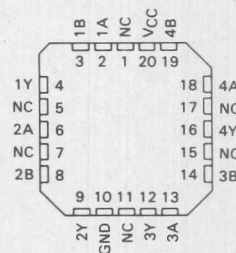
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

SN54HC00...J PACKAGE  
SN74HC00...J OR N OR D(=SO) PACKAGE  
(TOP VIEW)



SN54HC00...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HC MOS DEVICES

TYPES SN54HC00, SN74HC00  
QUADRUPLE 2-INPUT POSITIVE-NAND GATES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50\text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC00		SN74HC00		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		45	90		135		115	ns
			4.5 V		9	18		27		23	
			6 V		8	15		23		20	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC02, SN74HC02 QUADRUPE 2-INPUT POSITIVE-NOR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

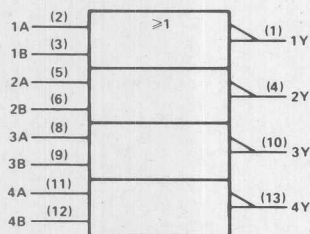
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain four independent 2-input NOR gates. They perform the Boolean functions  $Y = \bar{A} + \bar{B}$  or  $Y = \overline{A \cdot B}$  in positive logic.

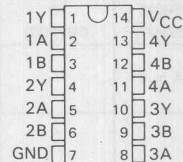
The SN54HC02 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC02 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

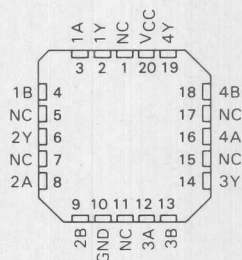


Pin numbers shown are for J and N packages.

### SN54HC02 ... J PACKAGE SN74HC02 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC02 ... FH OR FK PACKAGE (TOP VIEW)



NC — No internal connection

### FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	X	L
X	H	L
L	L	H

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-3.

3

HCMOS DEVICES

# **TYPES SN54HC02, SN74HC02** **QUADRUPLE 2-INPUT POSITIVE-NOR GATES**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  
 $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC02		SN74HC02		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		45	90		135		115	ns
			4.5 V		9	18		27		23	
			6 V		8	15		23		20	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	22 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC03, SN74HC03 QUADRUPLE 2-INPUT POSITIVE-NAND GATES WITH OPEN-DRAIN OUTPUTS

D2804, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

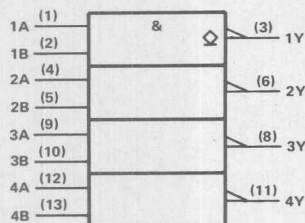
These devices contain four independent 2-input NAND gates. They perform the Boolean functions  $Y = \overline{A \cdot B}$  or  $Y = \overline{A + B}$  in positive logic. The open-drain outputs require pull-up resistors to perform correctly. They may be connected to other open-drain outputs to implement active-low wired-OR or active-high wired-AND functions.

The SN54HC03 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC03 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

### logic symbol

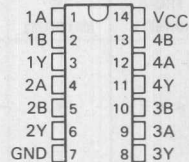


Pin numbers shown are for J and N packages.

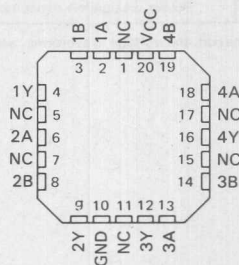
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

#### SN54HC03...J PACKAGE SN74HC03...J OR N OR D (= SO) PACKAGE (TOP VIEW)



#### SN54HC03...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

**TYPES SN54HC03, SN74HC03**  
**QUADRUPLE 2-INPUT POSITIVE-NAND GATES**  
**WITH OPEN-DRAIN OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $R_L = 1\text{ k}\Omega$ ,  $C_L = 50\text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC03		SN74HC03		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>PLH</sub>	A or B	Y	2 V		60	105		155		131	ns
			4.5 V		13	25		36		31	
			6 V		10	23		31		27	
t <sub>PHL</sub>			2 V		50	100		150		125	
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
t <sub>f</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>		Power dissipation capacitance per gate				No load, T <sub>A</sub> = 25°C				20 pF typ	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

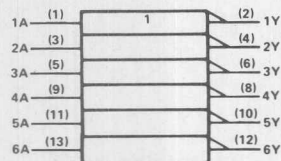
These devices contain six independent inverters. They perform the Boolean function  $Y = \bar{A}$ .

The SN54HC04 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC04 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE  
(each inverter)

INPUT	OUTPUT
A	Y
H	L
L	H

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

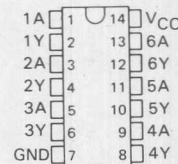
See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

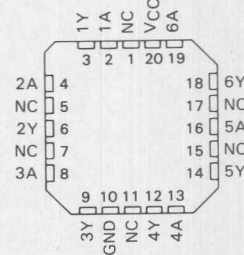
PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC04		SN74HC04		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	2 V		45	95		145		120	ns
			4.5 V		9	19		29		24	
			6 V		8	16		25		20	
t <sub>t</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance per inverter					No load, T <sub>A</sub> = 25°C			20 pF typ		

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

### SN54HC04...J PACKAGE SN74HC04...J OR N OR D(=SO) PACKAGE (TOP VIEW)



### SN54HC04...FH OR FK PACKAGE (TOP VIEW)



NC — No internal connection

3

HCMOS DEVICES

# CMOS LOGIC

- 1. Features: Outputs include 3-state Outputs (3S) and Complementary CMOS Outputs (CCO) and Complementary CMOS Outputs (CCO).
- 2. Outputs: Outputs include 3-state Outputs (3S) and Complementary CMOS Outputs (CCO) and Complementary CMOS Outputs (CCO).

These devices contain an independent 1.5V internal pull-up resistor for each output. They perform the Boolean function Y = A.

The 74VHC00 is characterized for operation over the full ambient temperature range of -55°C to +125°C. The 74VHC00 is characterized for operation from -40°C to 85°C.

FUNCTION TABLE

INPUT	OUTPUT
0	1
1	0



minimum, output, recommended operating conditions, and electrical characteristics.

See Table 1.

Electrical characteristics are recommended operating conditions (see Table 1).

PARAMETER	SYMBOL	UNIT	74VHC00		74VHC00	
			MIN	TYP	MIN	TYP
Supply Current	$I_{CC}$	mA	0.1	0.1	0.1	0.1
Output Current	$I_{OL}$	mA	10	10	10	10
Propagation Delay	$t_{PD}$	ns	10	10	10	10
Setup Time	$t_{SU}$	ns	10	10	10	10
Hold Time	$t_{HU}$	ns	10	10	10	10



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HCU04, SN74HCU04 HEX INVERTERS

D2804, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Unbuffered Outputs
- Dependable Texas Instruments Quality and Reliability

### description

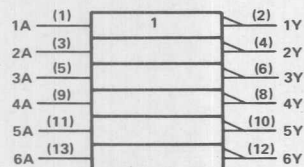
These devices contain six independent inverters. They perform the Boolean function  $Y = \overline{A}$ .

The SN54HCU04 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCU04 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE  
(each inverter)

INPUT A	OUTPUT Y
H	L
L	H

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table IX, page 2-16.

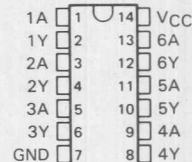
switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HCU04		SN74HCU04		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		40	80		120		100	ns
			4.5 V		8	16		24		20	
			6 V		7	14		20		17	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

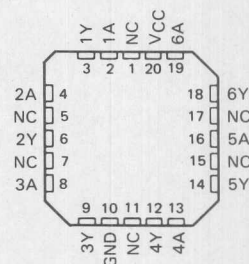
$C_{pd}$	Power dissipation capacitance per inverter	No load, $T_A = 25^{\circ}\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

SN54HCU04...J PACKAGE  
SN74HCU04...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCU04...FH OR FK PACKAGE  
(TOP VIEW)



NC - No internal connection

3

HCMOS DEVICES



- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

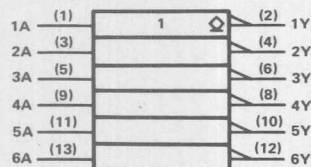
These devices contain six independent inverters. They perform the Boolean function  $Y = \bar{A}$ . The open-drain outputs require pull-up resistors to perform correctly. They may be connected to other open-drain outputs to implement active-low wired-OR or active-high wired-AND functions.

The SN54HC05 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC05 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE (each inverter)

INPUT A	OUTPUT Y
H	L
L	H

### logic symbol

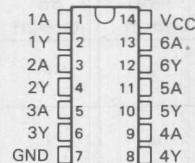


Pin numbers shown are for J and N packages.

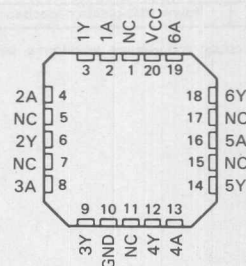
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

### SN54HC05...J PACKAGE SN74HC05...J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC05...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

3

HC MOS DEVICES

# **TYPES SN54HC05, SN74HC05** **HEX INVERTERS WITH OPEN-DRAIN OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC05		SN74HC05		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{PLH}$	A	Y	2 V		60	115		175		145	ns
			4.5 V		13	23		35		29	
			6 V		10	20		30		25	
$t_{PHL}$	A	Y	2 V		45	85		130		105	ns
			4.5 V		9	17		26		21	
			6 V		8	14		22		18	
$t_f$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per inverter	No load, $T_A = 25^\circ\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC08, SN74HC08 QUADRUPLE 2-INPUT POSITIVE-AND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

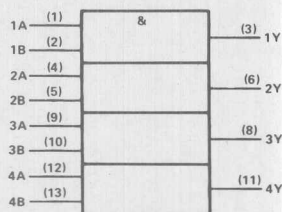
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These devices contain four independent 2-input AND gates. They perform the Boolean functions  $Y = A \cdot B$  or  $Y = \overline{A} + \overline{B}$  in positive logic.

The SN54HC08 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC08 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol



FUNCTION TABLE  
(each gate)

INPUTS		OUTPUT	
A	B	Y	
H	H	H	
L	X	L	
X	L	L	

Pin numbers shown are for J and N packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

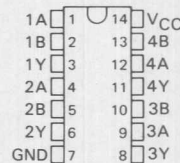
switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC08		SN74HC08		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

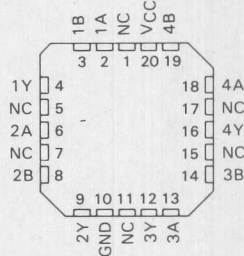
$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

SN54HC08 ... J PACKAGE  
SN74HC08 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC08 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES





## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC09, SN74HC09 QUADRUPLE 2-INPUT POSITIVE-AND GATES WITH OPEN-DRAIN OUTPUTS

D2804, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

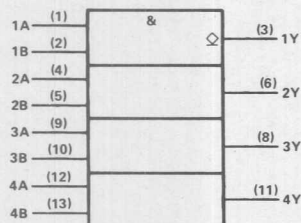
These devices contain four independent 2-input AND gates. They perform the Boolean functions  $Y = A \cdot B$  or  $Y = \bar{A} + \bar{B}$  in positive logic. The open-drain outputs require pull-up resistors to perform correctly. They may be connected to other open-drain outputs to implement active-low wired-OR or active-high wired-AND functions.

The SN54HC09 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC09 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

### logic symbol

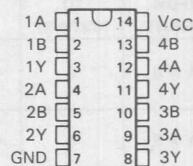


Pin numbers shown are for J and N packages.

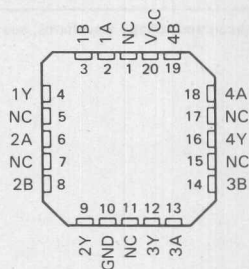
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

SN54HC09 ... J PACKAGE  
SN74HC09 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC09 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES

**TYPES SN54HC09, SN74HC09**  
**QUADRUPLE 2-INPUT POSITIVE-AND GATES WITH OPEN-DRAIN OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  
 $R_L = 1\text{ k}\Omega$ ,  $C_L = 50\text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC09		SN74HC09		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{PLH}$	A or B	Y	2 V		60	105		155		131	ns
			4.5 V		13	25		36		31	
			6 V		10	23		31		27	
$t_{PHL}$	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
$t_f$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC10, SN74HC10 TRIPLE 3-INPUT POSITIVE-NAND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

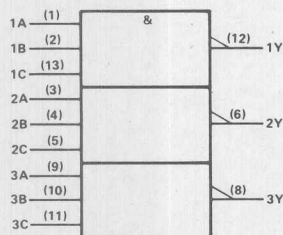
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain three independent 3-input NAND gates. They perform the Boolean functions  $Y = A \cdot B \cdot C$  or  $Y = \bar{A} + \bar{B} + \bar{C}$  in positive logic.

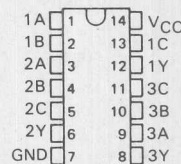
The SN54HC10 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC10 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

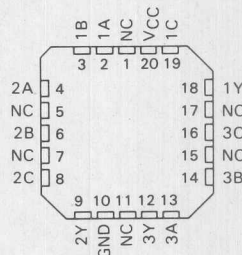


Pin numbers shown are for J and N packages.

### SN54HC10...J PACKAGE SN74HC10...J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC10...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

### FUNCTION TABLE (each gate)

INPUTS			OUTPUT
A	B	C	Y
H	H	H	L
L	X	X	H
X	L	X	H
X	X	L	H

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC10		SN74HC10		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Y	2 V		35	95		145		120	ns
			4.5 V		10	19		29		24	
			6 V		9	16		25		20	
$t_t$		Y	2 V		23	75		110		95	ns
			4.5 V		6	15		22		19	
			6 V		5	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

TEXAS  
INSTRUMENTS

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TABLE 3 INPUT POSITIVE-NAND GATES

DATA OF TABLE 3-1: REVERSE MODE

INPUTS: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100



TABLE 3-1: REVERSE MODE



TABLE 3-1: REVERSE MODE

INPUT	OUTPUT
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
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74	74
75	75
76	76
77	77
78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

TABLE 3-1: REVERSE MODE

TABLE 3-1: REVERSE MODE

INPUT	OUTPUT
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
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80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

TABLE 3-1: REVERSE MODE

TABLE 3-1: REVERSE MODE

TABLE 3-1: REVERSE MODE

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC11, SN74HC11 TRIPLE 3-INPUT POSITIVE-AND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

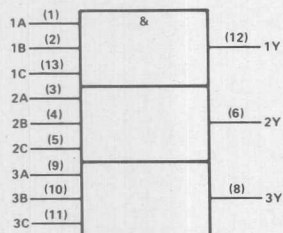
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain three independent 3-input AND gates. They perform the Boolean functions  $Y = A \cdot B \cdot C$  or  $Y = \bar{A} + \bar{B} + \bar{C}$  in positive logic.

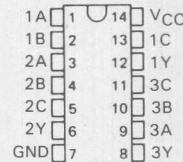
The SN54HC11 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC11 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

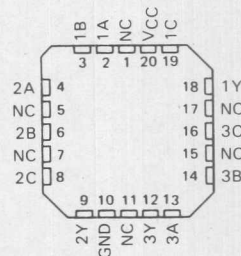


Pin numbers shown are for J and N packages.

SN54HC11...J PACKAGE  
SN74HC11...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC11...FH OR FK PACKAGE  
(TOP VIEW)



NC — No internal connection

FUNCTION TABLE (each gate)

INPUTS			OUTPUT
A	B	C	Y
H	H	H	H
L	X	X	L
X	L	X	L
X	X	L	L

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC11		SN74HC11		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Y	2 V		35	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
$t_t$		Y	2 V		25	75		110		95	ns
			4.5 V		7	15		22		19	
			6 V		5	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC14, SN74HC14 HEX SCHMITT-TRIGGER INVERTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

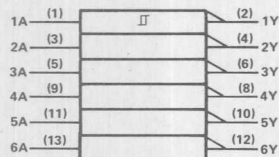
These Schmitt-trigger devices contain six independent inverters. They perform the Boolean function  $Y = \bar{A}$ .

The SN54HC14 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC14 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE  
(each inverter)

INPUT A	OUTPUT Y
H	L
L	H

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

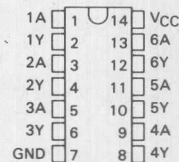
See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

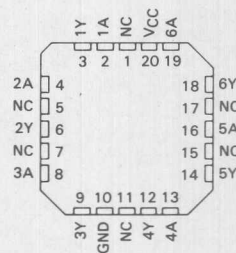
PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC14		SN74HC14		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	2 V		55	125		190		155	ns
			4.5 V		12	25		38		31	
			6 V		11	21		32		26	
t <sub>t</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance per inverter			No load, T <sub>A</sub> = 25°C				20 pF typ			

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

SN54HC14...J PACKAGE  
SN74HC14...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC14...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC20, SN74HC20 DUAL 4-INPUT POSITIVE-NAND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

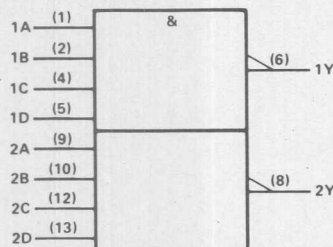
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These devices contain two independent 4-input NAND gates. They perform the Boolean functions  $Y = \overline{A \cdot B \cdot C \cdot D}$  or  $Y = \overline{\overline{A} + \overline{B} + \overline{C} + \overline{D}}$  in positive logic.

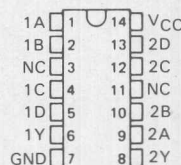
The SN54HC20 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC20 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol

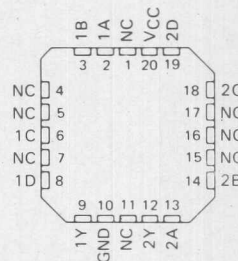


Pin numbers shown are for J and N packages.

## SN54HC20... J PACKAGE SN74HC20... J OR N OR D (= SO) PACKAGE (TOP VIEW)



## SN54HC20... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

## FUNCTION TABLE (each gate)

INPUTS				OUTPUT
A	B	C	D	Y
H	H	H	H	L
L	X	X	X	H
X	L	X	X	H
X	X	L	X	H
X	X	X	L	H

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	VCC	$T_A = 25^{\circ}\text{C}$			SN54HC20		SN74HC20		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, C, or D	Y	2 V		45	110		165		140	ns
			4.5 V		14	22		33		28	
			6 V		11	19		28		24	
$t_t$		Y	2 V		27	75		110		95	ns
			4.5 V		9	15		22		19	
			6 V		7	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC21, SN74HC21 DUAL 4-INPUT POSITIVE-AND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

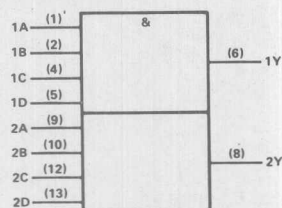
## description

These devices contain two independent 4-input AND gates. They perform the Boolean functions  $Y = A \cdot B \cdot C \cdot D$  or  $Y = \bar{A} + \bar{B} + \bar{C} + \bar{D}$  in positive logic.

The SN54HC21 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

The SN74HC21 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol



FUNCTION TABLE (each gate)

INPUTS				OUTPUT
A	B	C	D	Y
H	H	H	H	H
L	X	X	X	L
X	L	X	X	L
X	X	L	X	L
X	X	X	L	L

Pin numbers shown are for J and N packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

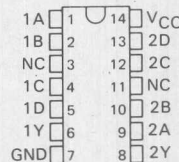
switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC21		SN74HC21		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, C, or D	Y	2 V		44	110		165		140	ns
			4.5 V		14	22		33		28	
			6 V		11	19		28		24	
$t_t$		Y	2 V		29	75		110		95	ns
			4.5 V		10	15		22		19	
			6 V		8	13		19		16	

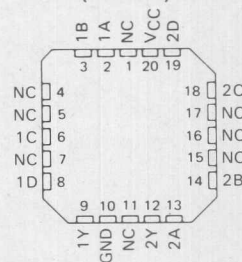
$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

SN54HC21...J PACKAGE  
SN74HC21...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC21...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES





# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC27, SN74HC27 TRIPLE 3-INPUT POSITIVE-NOR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

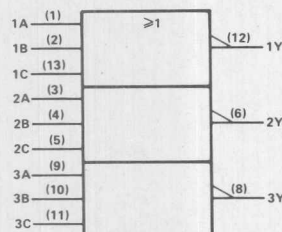
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain three independent 3-input NOR gates. They perform the Boolean functions  $Y = A + B + C$  or  $Y = \overline{A \cdot B \cdot C}$  in positive logic.

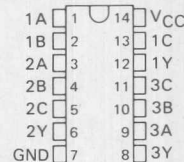
The SN54HC27 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC27 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

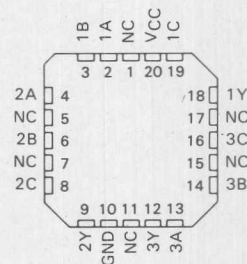


Pin numbers shown are for J and N packages.

SN54HC27... J PACKAGE  
SN74HC27... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC27... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE (each gate)

INPUTS			OUTPUT
A	B	C	Y
H	X	X	L
X	H	X	L
X	X	H	L
L	L	L	H

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC27		SN74HC27		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Y	2 V		35	90		135		115	ns
			4.5 V		10	18		27		23	
			6 V		9	15		23		20	
$t_t$		Y	2 V		27	75		110		95	ns
			4.5 V		7	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC30, SN74HC30 8-INPUT POSITIVE-NAND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

## description

These devices contain a single 8-input NAND gate and perform the following Boolean functions in positive logic:

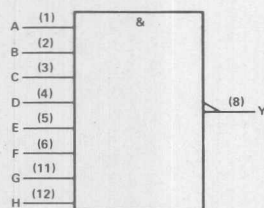
$$Y = \overline{A \cdot B \cdot C \cdot D \cdot E \cdot F \cdot G \cdot H}$$

or

$$Y = \overline{A + B + C + D + E + F + G + H}$$

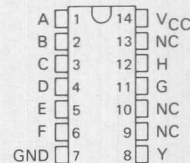
The SN54HC30 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC30 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol

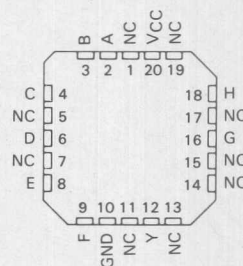


Pin numbers shown are for J and N packages.

## SN54HC30...J PACKAGE SN74HC30...J OR N OR D (= SO) PACKAGE (TOP VIEW)



## SN54HC30...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

## FUNCTION TABLE

INPUTS A THRU H	OUTPUT Y
All inputs H	L
One or more inputs L	H

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC30		SN74HC30		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A thru H	Y	2 V	51	130		195			165	ns
			4.5 V	15	26		39			33	
			6 V	12	22		33			28	
$t_t$		Y	2 V	28	75		110			95	ns
			4.5 V	8	15		22			19	
			6 V	6	13		19			16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	22 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC32, SN74HC32 QUADRUPLE 2-INPUT POSITIVE-OR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

### description

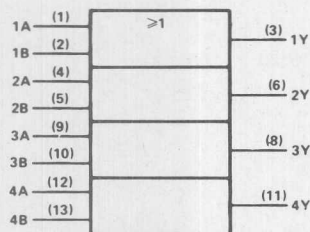
These devices contain four independent 2-input OR gates. They perform the Boolean functions  $Y = A + B$  or  $Y = \bar{A} + \bar{B}$  in positive logic.

The SN54HC32 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC32 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE  
(each gate)

INPUTS		OUTPUT
A	B	Y
H	X	H
X	H	H
L	L	L

### logic symbol

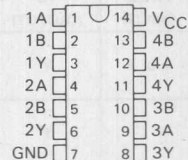


Pin numbers shown are for J and N packages.

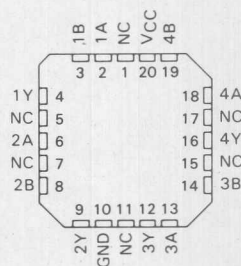
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

SN54HC32... J PACKAGE  
SN74HC32... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC32... FH OR FK PACKAGE  
(TOP VIEW)



NC — No internal connection

3

HCMOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  
 $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC32		SN74HC32		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
t <sub>t</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C					20 pF typ

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC36, SN74HC36 QUADRUPLE 2-INPUT POSITIVE-NOR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

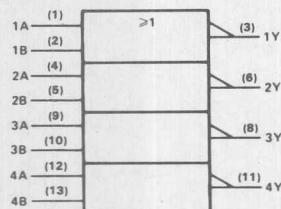
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These devices contain four independent 2-input NOR gates. They perform the Boolean functions  $Y = A + B$  or  $Y = \overline{A \cdot B}$  in positive logic.

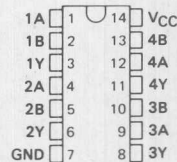
The SN54HC36 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC36 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol

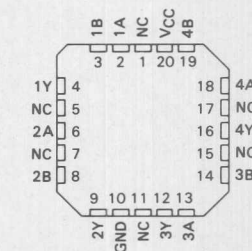


Pin numbers shown are for J and N packages.

SN54HC36...J PACKAGE  
SN74HC36...J OR N OR D(=SO) PACKAGE  
(TOP VIEW)



SN54HC36...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	X	L
X	H	L
L	L	H

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC36		SN74HC36		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	20 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# QUAD 2-INPUT POSITIVE-NAND GATES

Logic Symbol and Pin Connections

Pin 1: Ground (GND)  
Pin 2: Input A  
Pin 3: Input B  
Pin 4: Output Y



Pin 1: Ground (GND)  
Pin 2: Input A  
Pin 3: Input B  
Pin 4: Output Y



Pin 1: Ground (GND)  
Pin 2: Input A  
Pin 3: Input B  
Pin 4: Output Y

Pin	Function
1	GND
2	A
3	B
4	Y

Maximum ratings: recommended operating conditions, and electrical characteristics

See Table 1, page 1-4

Switching characteristics: see recommended operating conditions and electrical characteristics

Parameter	Symbol	Units	Typical Value	Maximum Value
Supply Current	$I_{CC}$	mA	1.0	2.0
Input Current	$I_{I1}$	mA	0.1	0.5
Output Current	$I_{O1}$	mA	10	20
Propagation Delay	$t_{PD}$	ns	10	20
Setup Time	$t_{SU}$	ns	10	20
Hold Time	$t_{HO}$	ns	10	20

Notes: 1. All values are at  $T_A = 25^\circ\text{C}$  unless otherwise specified.

2. Load capacitance  $C_L = 50\text{ pF}$ .

3. Input and output voltages are  $V_{DD} = 5.0\text{ V}$  and  $V_{SS} = 0\text{ V}$ .

4. Propagation delay is measured from the 50% point of the input signal to the 50% point of the output signal.

5. Setup and hold times are measured with respect to the 50% point of the input signal.

6. Output current is measured with the output connected to a load resistor  $R_L = 1\text{ k}\Omega$ .

7. Input current is measured with the input connected to a voltage source  $V_I = 5.0\text{ V}$ .

8. Supply current is measured with the output connected to a load resistor  $R_L = 1\text{ k}\Omega$ .

9. All values are at  $T_A = 25^\circ\text{C}$  unless otherwise specified.

10. Load capacitance  $C_L = 50\text{ pF}$ .

11. Input and output voltages are  $V_{DD} = 5.0\text{ V}$  and  $V_{SS} = 0\text{ V}$ .

12. Propagation delay is measured from the 50% point of the input signal to the 50% point of the output signal.

13. Setup and hold times are measured with respect to the 50% point of the input signal.

14. Output current is measured with the output connected to a load resistor  $R_L = 1\text{ k}\Omega$ .

15. Input current is measured with the input connected to a voltage source  $V_I = 5.0\text{ V}$ .

16. Supply current is measured with the output connected to a load resistor  $R_L = 1\text{ k}\Omega$ .

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC42, SN74HC42 4-LINE TO 10-LINE DECODERS (1-of-10)

D2684, DECEMBER 1982—REVISED MARCH 1984

- Full Decoding of Input Logic
- All Outputs Are High for Invalid BCD Conditions
- Also for Application as 3-Line to 8-Line Decoders
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

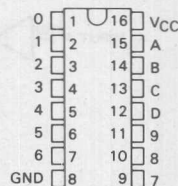
These monolithic decimal decoders consist of eight inverters and ten four-input NAND gates. The inverters are connected in pairs to make BCD input data available for decoding by the NAND gates. Full decoding of valid input logic ensures that all inputs remain off for all invalid input conditions.

The SN54HC42 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC42 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

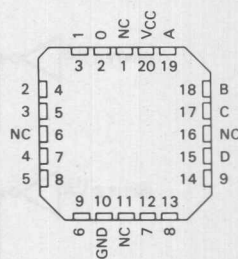
FUNCTION TABLE

NO.	INPUTS				OUTPUTS									
	D	C	B	A	0	1	2	3	4	5	6	7	8	9
0	L	L	L	L	L	H	H	H	H	H	H	H	H	H
1	L	L	L	H	H	L	H	H	H	H	H	H	H	H
2	L	L	H	L	H	H	L	H	H	H	H	H	H	H
3	L	L	H	H	H	H	L	H	H	H	H	H	H	H
4	L	H	L	L	H	H	H	L	H	H	H	H	H	H
5	L	H	L	H	H	H	H	H	L	H	H	H	H	H
6	L	H	H	L	H	H	H	H	H	L	H	H	H	H
7	L	H	H	H	H	H	H	H	H	H	L	H	H	H
8	H	L	L	L	H	H	H	H	H	H	H	L	H	H
9	H	L	L	H	H	H	H	H	H	H	H	H	L	H
INVALID	H	L	H	L	H	H	H	H	H	H	H	H	H	H
	H	L	H	H	H	H	H	H	H	H	H	H	H	H
	H	H	L	L	H	H	H	H	H	H	H	H	H	H
	H	H	L	H	H	H	H	H	H	H	H	H	H	H
	H	H	H	L	H	H	H	H	H	H	H	H	H	H

SN54HC42... J PACKAGE  
SN74HC42... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

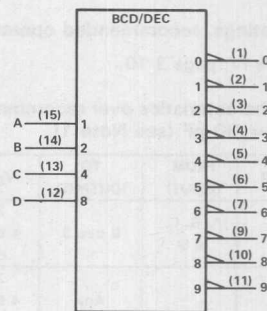


SN54HC42... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol

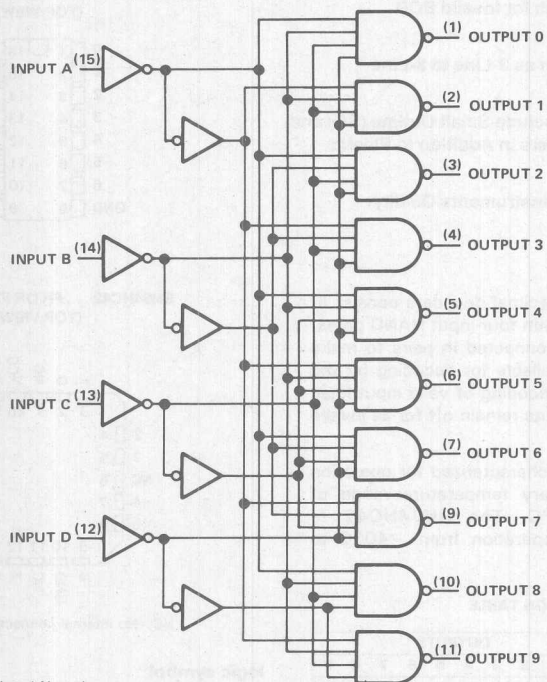


Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

**switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC42		SN74HC42		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, C, or D	0 thru 9	2 V		65	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		14	26		38		32	
$t_t$		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		7	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	39 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC51, SN74HC51 AND-OR-INVERT GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

### description

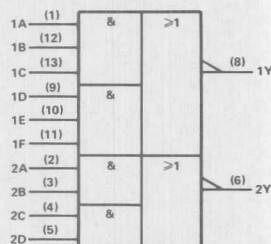
The 'HC51 provides 2-wide, 2-input, and 2-wide, 3-input AND-OR-INVERT gates. The device performs the following Boolean functions:

$$1Y = (1A \cdot 1B \cdot 1C) + (1D \cdot 1E \cdot 1F)$$

$$2Y = (2A \cdot 2B) + (2C \cdot 2D)$$

The SN54HC51 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC51 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol



FUNCTION TABLES							
INPUTS							OUTPUT
1A	1B	1C	1D	1E	1F	1Y	
H	H	H	X	X	X	L	
X	X	X	H	H	H	L	
Any other combination							H

INPUTS					OUTPUT
2A	2B	2C	2D	2Y	
H	H	X	X	L	
X	X	H	H	L	
Any other combination					H

Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

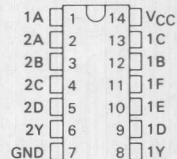
switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC51		SN74HC51		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any	Y	2 V		54	140		210		175	ns
			4.5 V		15	28		42		35	
			6 V		12	24		36		30	
$t_t$		Y	2 V		28	75		110		95	ns
			4.5 V		9	15		22		19	
			6 V		8	13		19		16	

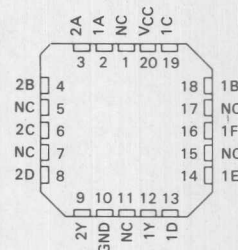
$C_{pd}$	Power dissipation capacitance per AOI gate	No load, $T_A = 25^{\circ}\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

### SN54HC51 ... J PACKAGE SN74HC51 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC51 ... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

3

HC MOS DEVICES





# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC74, SN74HC74 DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH CLEAR AND PRESET

D2684, DECEMBER 1982—REVISED JUNE 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain two independent D-type positive-edge-triggered flip-flops. A low level at the Preset or Clear inputs sets or resets the outputs regardless of the levels of the other inputs. When Preset and Clear are inactive (high), data at the D input meeting the setup time requirements are transferred to the outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the D input may be changed without affecting the levels at the outputs.

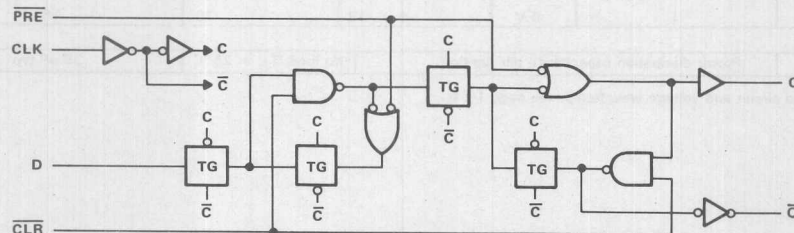
The SN54HC74 is characterized for operation over the full military temperature range  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC74 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

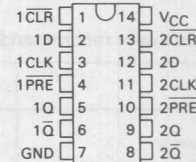
INPUTS				OUTPUTS	
PRE	CLR	CLK	D	Q	$\bar{Q}$
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	$H^{\dagger}$	$H^{\dagger}$
H	H	$\uparrow$	H	H	L
H	H	$\uparrow$	L	L	H
H	H	L	X	$Q_0$	$\bar{Q}_0$

$\dagger$ This configuration is nonstable; that is, it will not persist when Preset or Clear returns to its inactive (high) level.

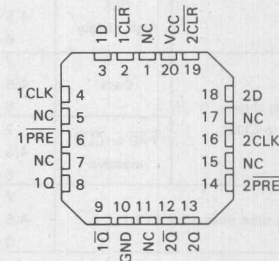
### logic diagram, each flip-flop (positive logic)



SN54HC74...J PACKAGE  
SN74HC74...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

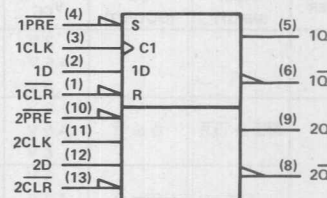


SN54HC74...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

# **TYPES SN54HC74, SN74HC74** **DUAL D-TYPE POSITIVE-EDGE-TRIGGERED** **FLIP-FLOPS WITH CLEAR AND PRESET**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		VCC	TA = 25°C		SN54HC74		SN74HC74		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
fclock	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
tw	Pulse duration	PRE or CLR low	2 V	100	150	125	ns		
		4.5 V	20	30	25				
		6 V	17	25	21				
	CLK high or low	2 V	80	120	100				
		4.5 V	16	24	20				
		6 V	14	20	17				
tsu	Setup time before CLK †	Data	2 V	100	150	125	ns		
		4.5 V	20	30	25				
		6 V	17	25	21				
	PRE or CLR inactive	2 V	25	40	30				
		4.5 V	5	8	6				
		6 V	4	7	5				
th	Hold time data after CLK †	2 V	0	0	0	ns			
		4.5 V	0	0	0				
		6 V	0	0	0				

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC74		SN74HC74		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	10		4.2		5		MHz
			4.5 V	31	50		20		25		
			6 V	36	60		25		29		
t <sub>pd</sub>	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$	Q or $\overline{\text{Q}}$	2 V		70	230		345		290	ns
			4.5 V		20	46		69		58	
			6 V		15	39		59		49	
	CLK	Q or $\overline{\text{Q}}$	2 V		70	175		250		220	
			4.5 V		20	35		50		44	
			6 V		15	30		42		37	
t <sub>t</sub>		Q or $\overline{\text{Q}}$	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

D2684, DECEMBER 1982—REVISED MARCH 1984

- Complementary Q and  $\bar{Q}$  Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

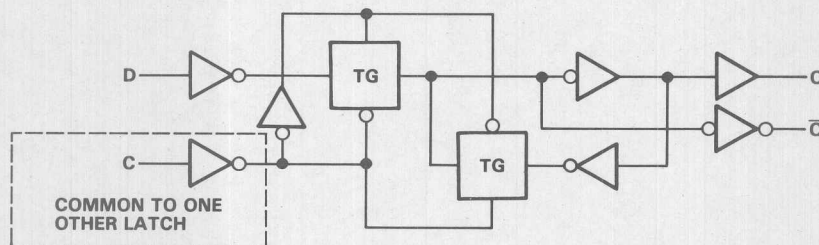
These latches are ideally suited for use as temporary storage for binary information between processing units and input/output or indicator units. Information present at a data (D) input is transferred to the Q output when the enable (C) is high and the Q output will follow the data input as long as the enable remains high. When the enable goes low, the information (that was present at the data input at the time the transition occurred) is retained at the Q output until the enable is permitted to go high.

The SN54HC75 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC75 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

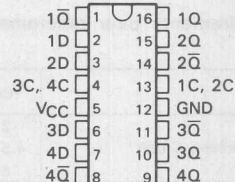
FUNCTION TABLE  
(Each Latch)

INPUTS		OUTPUTS	
D	C	Q	$\bar{Q}$
L	H	L	H
H	H	H	L
X	L	$Q_0$	$\bar{Q}_0$

## logic diagram, each latch (positive logic)

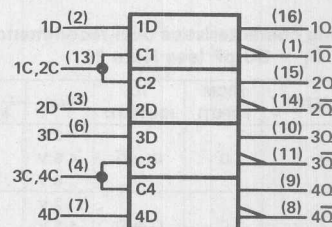


SN54HC75... J PACKAGE  
SN74HC75... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



For functionally and electrically identical parts in chip carrier packages, see SN54HC375 and SN74HC375.

## logic symbol



Pin numbers shown are for J and N packages.

3

HCNOS DEVICES

# **TYPES SN54HC75, SN74HC75** **4-BIT BISTABLE LATCHES**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC75		SN74HC75		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before C ↓	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
t <sub>h</sub> Hold time, data after C ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC75		SN74HC75		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q or $\bar{Q}$	2 V		40	120		180		150	ns
			4.5 V		14	24		36		30	
			6 V		11	20		31		26	
t <sub>pd</sub>	C	Q or $\bar{Q}$	2 V		44	130		195		165	ns
			4.5 V		15	26		39		33	
			6 V		12	22		33		28	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	46 pF typ
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NOTE 1: For load circuits and voltage waveforms, see page 1-14.

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC76, SN74HC76 DUAL J-K FLIP-FLOPS WITH CLEAR AND PRESET

D2684, DECEMBER 1982 - REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

### description

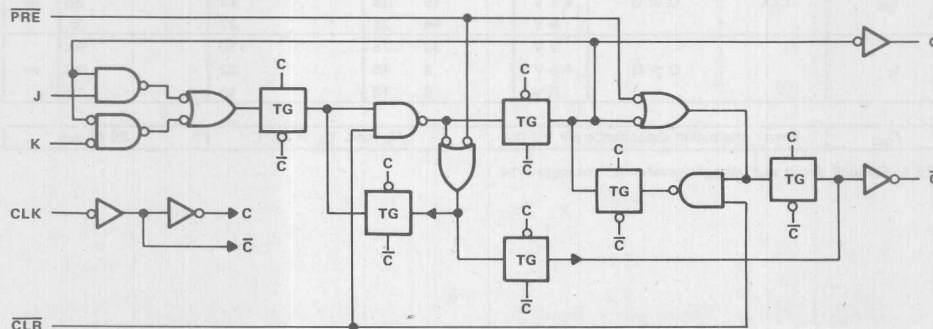
These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the Preset or Clear input sets or resets the outputs regardless of the levels of the other inputs. When Preset and Clear are inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can also perform as toggle flip-flops by tying J and K high.

FUNCTION TABLE  
(EACH FLIP-FLOP)

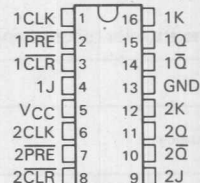
INPUTS					OUTPUTS	
PRE	CLR	CLK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	$\downarrow$	L	L	$Q_0$	$\bar{Q}_0$
H	H	$\downarrow$	H	L	H	L
H	H	$\downarrow$	L	H	L	H
H	H	$\downarrow$	H	H	TOGGLE	TOGGLE
H	H	H	X	X	$Q_0$	$\bar{Q}_0$

\*This configuration is nonstable; that is, it will not persist when either Preset or Clear returns to its inactive (high) level.

### logic diagram, each flip-flop (positive logic)

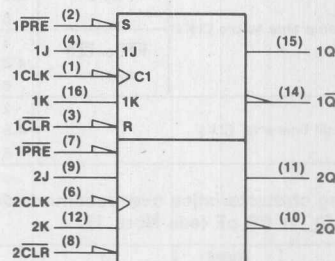


SN54HC76 ... J PACKAGE  
SN74HC76 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



For functionally and electrically identical parts in chip carrier packages, see SN54HC112 and SN74HC112.

### logic symbol



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

TEXAS  
INSTRUMENTS

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# **TYPES SN54HC76, SN74HC76** **DUAL J-K FLIP-FLOPS WITH CLEAR AND PRESET**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC76		SN74HC76		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$ low	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	17	25		21		
	CLK high or low		2 V	80	120		100		
			4.5 V	16	24		20		
			6 V	14	20		17		
t <sub>su</sub>	Setup time before CLK↓	Data	2 V	150	225		190		ns
			4.5 V	30	45		38		
			6 V	25	38		32		
	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$ inactive		2 V	100	150		125		
			4.5 V	20	30		25		
			6 V	17	25		21		
t <sub>h</sub>	Hold time after CLK↓		2 V	0	0		0		ns
			4.5 V	0	0		0		
			6 V	0	0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC76		SN74HC76		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	9		4.2		5		MHz
			4.5 V	31	41		21		25		
			6 V	36	50		25		29		
t <sub>pd</sub>	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$	Q or $\overline{\text{Q}}$	2 V		65	155		250		190	ns
			4.5 V		16	31		47		39	
			6 V		15	26		40		33	
t <sub>pd</sub>	CLK	Q or $\overline{\text{Q}}$	2 V		70	145		220		180	ns
			4.5 V		19	29		44		36	
			6 V		16	25		37		31	
t <sub>t</sub>		Q or $\overline{\text{Q}}$	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	36 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC77, SN74HC77 4-BIT BISTABLE LATCHES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

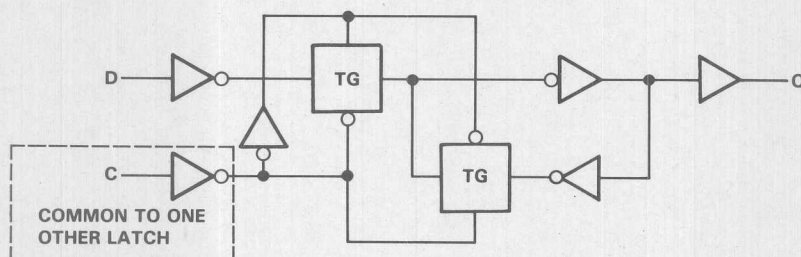
These latches are ideally suited for use as temporary storage for binary information between processing units and input/output or indicator units. Information present at a data (D) input is transferred to the Q output when the enable (C) is high and the Q output will follow the data input as long as the enable remains high. When the enable goes low, the information (that was present at the data input at the time the transition occurred) is retained at the Q output until the enable is permitted to go high.

The SN54HC77 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC77 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

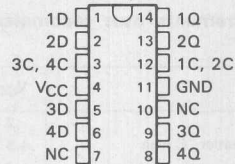
FUNCTION TABLE  
(Each Latch)

INPUTS		OUTPUT
D	C	Q
L	H	L
H	H	H
X	L	Q <sub>0</sub>

### logic diagram, each latch (positive logic)



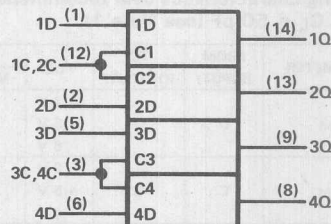
SN54HC77... J PACKAGE  
SN74HC77... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



NC—No internal connection

Not available in chip carrier package with JEDEC-Standard pin-out. For chip carrier information, contact the factory.

### logic symbol



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

# **TYPES SN54HC77, SN74HC77** **4-BIT BISTABLE LATCHES**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC77		SN74HC77		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>W</sub> Pulse duration, C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before C ↓	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
t <sub>h</sub> Hold time, data after C ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC77		SN74HC77		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	2 V		40	120		180		150	ns
			4.5 V		12	24		36		30	
			6 V		10	20		31		26	
t <sub>pd</sub>	C	Q	2 V		45	130		195		165	ns
			4.5 V		14	26		39		33	
			6 V		11	22		33		28	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

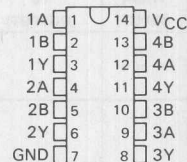
## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC86, SN74HC86 QUADRUPLE 2-INPUT EXCLUSIVE-OR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC86... J PACKAGE  
SN74HC86... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



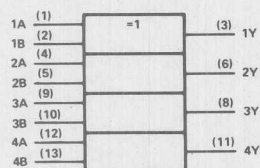
### description

These devices contain four independent 2-input Exclusive-OR gates. They perform the Boolean functions  $Y = A \oplus B = \overline{A}B + A\overline{B}$  in positive logic.

A common application is as a true/complement element. If one of the inputs is low, the other input will be reproduced in true form at the output. If one of the inputs is high, the signal on the other input will be reproduced inverted at the output.

The SN54HC86 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC86 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol



FUNCTION TABLE  
(each gate)

INPUTS		OUTPUT
A	B	Y
L	L	L
L	H	H
H	L	H
H	H	L

Pin numbers shown are for J and N packages.

### exclusive-OR logic

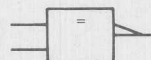
An exclusive-OR gate has many applications, some of which can be represented better by alternative logic symbols.

#### EXCLUSIVE-OR



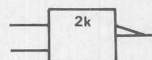
These are five equivalent Exclusive-OR symbols valid for an 'HC86 gate in positive logic; negation may be shown at any two ports.

#### LOGIC IDENTITY ELEMENT



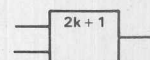
The output is active (low) if all inputs stand at the same logic level (i.e.,  $A = B$ ).

#### EVEN-PARITY



The output is active (low) if an even number of inputs (i.e., 0 or 2) are active.

#### ODD-PARITY ELEMENT



The output is active (high) if an odd number of inputs (i.e., only 1 of the 2) are active.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

# **TYPES SN54HC86, SN74HC86** **QUADRUPL 2-INPUT EXCLUSIVE-OR GATES**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC86		SN74HC86		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40	100		150		125	ns
			4.5 V		12	20		30		25	
			6 V		10	17		25		21	
$t_t$		Y	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

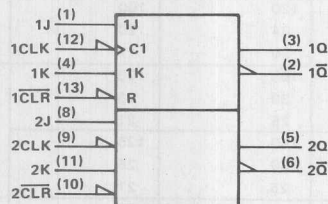
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the  $\overline{\text{CLR}}$  input resets the outputs regardless of the levels of the other inputs. When  $\overline{\text{CLR}}$  is inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can perform as toggle flip-flops by tying J and K high.

The SN54HC107 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC107 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

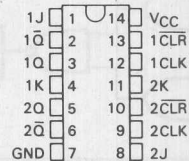


Pin numbers shown are for J and N packages.

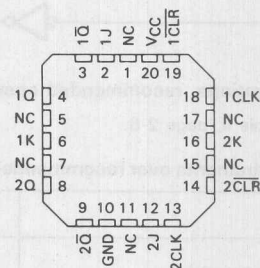
## TYPES SN54HC107, SN74HC107 DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS WITH CLEAR

D2684, DECEMBER 1982—REVISED MARCH 1984

### SN54HC107 ... J PACKAGE SN74HC107 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC107 ... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

### FUNCTION TABLE

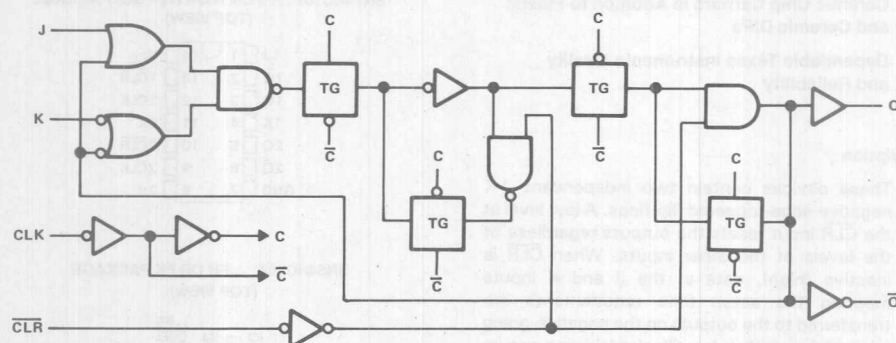
INPUTS				OUTPUTS	
$\overline{\text{CLR}}$	CLK	J	K	Q	$\overline{\text{Q}}$
L	X	X	X	L	H
H	↓	L	L	$\text{Q}_0$	$\overline{\text{Q}}_0$
H	↓	H	L	H	L
H	↓	L	H	L	H
H	↓	H	H	TOGGLE	
H	H	X	X	$\text{Q}_0$	$\overline{\text{Q}}_0$

3

HCMOS DEVICES

**TYPES SN54HC107, SN74HC107**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED**  
**FLIP-FLOPS WITH CLEAR**

logic diagram, each flip-flop (positive logic)



**3**

**HC MOS DEVICES**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC107		SN74HC107		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK high or low	2 V	80		120		100		
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub>	Setup time before CLK ↓	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLR inactive	2 V	100		150		125		
		4.5 V	20		30		25		
		6 V	17		25		21		
t <sub>h</sub>	Hold time, data after CLK ↓	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		



**TYPES SN54HC107, SN74HC107**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED**  
**FLIP-FLOPS WITH CLEAR**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC107		SN74HC107		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	6	9		4.2		5		MHz
			4.5 V	31	45		21		25		
			6 V	36	53		25		29		
$t_{pd}$	$\overline{\text{CLR}}$	Q or $\overline{Q}$	2 V		126	155		235		195	ns
			4.5 V		25	31		47		39	
			6 V		21	26		40		32	
$t_{pd}$	CLK	Q or $\overline{Q}$	2 V		100	125		185		160	ns
			4.5 V		20	25		37		32	
			6 V		17	21		32		27	
$t_t$		Q or $\overline{Q}$	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per flip-flop	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC109, SN74HC109 DUAL J-K POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH CLEAR AND PRESET

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain two independent J-K positive-edge-triggered flip-flops. A low level at the Preset or Clear inputs sets or resets the outputs regardless of the levels of the other inputs. When Preset and Clear are inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can perform as toggle flip-flops by grounding K and tying J high. They also can perform as D-type flip-flops if J and K are tied together.

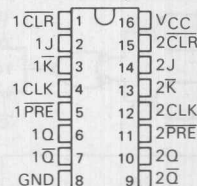
The SN54HC109 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC109 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

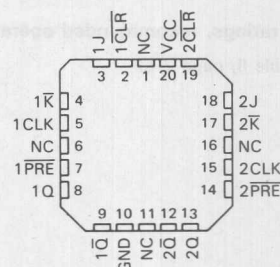
INPUTS					OUTPUTS	
PRE	CLR	CLK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	↑	L	L	L	H
H	H	↑	H	L	TOGGLE	
H	H	↑	L	H	$Q_0$	$\bar{Q}_0$
H	H	↑	H	H	H	L
H	H	L	X	X	$Q_0$	$\bar{Q}_0$

\* This configuration is nonstable; that is, it will not persist when Preset or Clear return to their inactive (high) level.

### SN54HC109...J PACKAGE SN74HC109...J OR N OR D(=SO) PACKAGE (TOP VIEW)

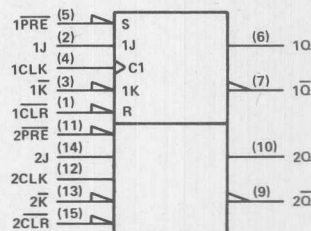


### SN54HC109...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

### logic symbol



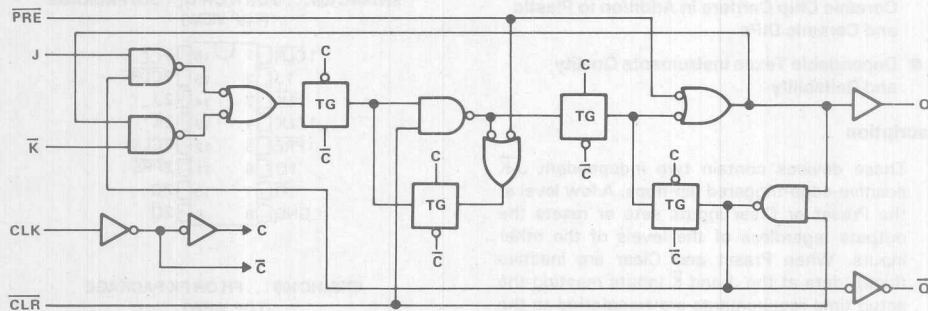
Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

# **TYPES SN54HC109, SN74HC109** **DUAL J-K POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH CLEAR AND PRESET**

logic diagram, each flip-flop (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

3

HCMOS DEVICES

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC109		SN74HC109		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK high or low	2 V	80		120		100		
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub>	Setup time before CLK ↑	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$ inactive	2 V	25		40		30		
		4.5 V	5		8		6		
		6 V	4		7		5		
t <sub>h</sub>	Hold time, data after CLK ↑	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC109		SN74HC109		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	10		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		29		
t <sub>pd</sub>	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$	Q or $\overline{\text{Q}}$	2 V		60	230		345		290	ns
			4.5 V		15	46		69		58	
			6 V		12	39		59		49	
t <sub>pd</sub>	CLK	Q or $\overline{\text{Q}}$	2 V		50	175		250		220	ns
			4.5 V		15	35		50		44	
			6 V		12	30		42		37	
t <sub>t</sub>		Q or $\overline{\text{Q}}$	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# 3 HCMOS DEVICES



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC112, SN74HC112 DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS WITH CLEAR AND PRESET

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

### description

These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the Preset or Clear inputs sets or resets the outputs regardless of the levels of the other inputs. When Preset and Clear are inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can perform as toggle flip-flops by tying J and K high.

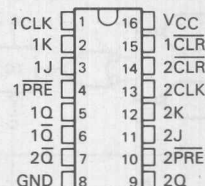
The SN54HC112 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC112 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

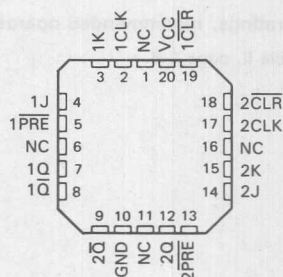
INPUTS					OUTPUTS	
PRE	CLR	CLK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	$\downarrow$	L	L	$Q_0$	$\bar{Q}_0$
H	H	$\downarrow$	H	L	H	L
H	H	$\downarrow$	L	H	L	H
H	H	$\downarrow$	H	H	TOGGLE	
H	H	H	X	X	$Q_0$	$\bar{Q}_0$

\*This configuration is nonstable; that is, it will not persist when either Preset or Clear returns to its inactive (high) level.

### SN54HC112... J PACKAGE SN74HC112... J OR N OR D (= SO) PACKAGE (TOP VIEW)

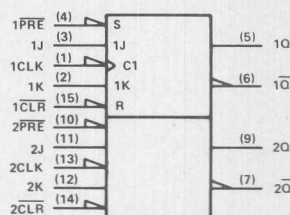


### SN54HC112... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

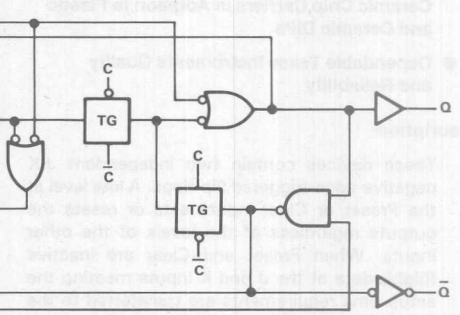
### logic symbol



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES



## ions, and electrical characteristics

## HCMOS DEVICES

**TYPES SN54HC112, SN74HC112**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS**  
**WITH CLEAR AND PRESET**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC112		SN74HC112		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5	0	3.3	0	4	MHz
		4.5 V	0	25	0	17	0	20	
		6 V	0	29	0	20	0	24	
t <sub>w</sub>	Pulse duration	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK high or low	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
t <sub>su</sub>	Setup time before CLK↓	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	PRE or CLR inactive	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
t <sub>h</sub>	Hold time, data after CLK↓	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC112		SN74HC112		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	10		3.3		4		MHz
			4.5 V	25	50		17		20		
			6 V	29	60		20		24		
t <sub>pd</sub>	PRE or CLR	Q or Q̄	2 V		54	165		245		205	ns
			4.5 V		16	33		49		41	
			6 V		13	28		42		35	
t <sub>pd</sub>	CLK	Q or Q̄	2 V		56	125		185		155	ns
			4.5 V		16	25		37		31	
			6 V		13	21		31		26	
t <sub>t</sub>		Q or Q̄	2 V		29	75		110		95	ns
			4.5 V		9	15		22		19	
			6 V		8	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HCMOS DEVICES

**TYPES SN54HC113, SN74HC113  
DUAL J-K NEGATIVE-EDGE-TRIGGERED  
FLIP-FLOPS WITH PRESET**

D2684. DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

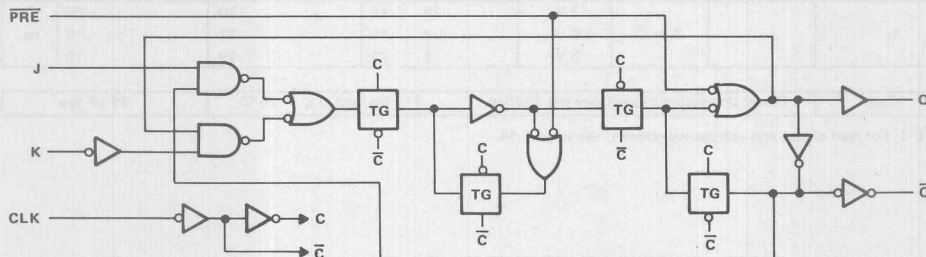
These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the Preset input sets the outputs regardless of the levels of the other inputs. When Preset ( $\overline{\text{PRE}}$ ) is inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the outputs. These versatile flip-flops can perform as toggle flip-flops by tying J and K high.

The SN54HC113 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC113 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### FUNCTION TABLE

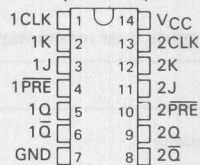
INPUTS				OUTPUTS	
$\overline{\text{PRE}}$	CLK	J	K	Q	$\overline{Q}$
L	X	X	X	H	L
H	↓	L	L	Q <sub>0</sub>	$\overline{Q_0}$
H	↓	H	L	H	L
H	↓	L	H	L	H
H	↓	H	H	TOGGLE	
H	H	X	X	Q <sub>0</sub>	$\overline{Q_0}$

logic diagram, each flip-flop (positive logic)

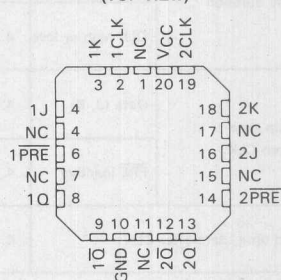


Pin numbers shown are for J and N packages.

SN54HC113...J PACKAGE  
SN74HC113...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

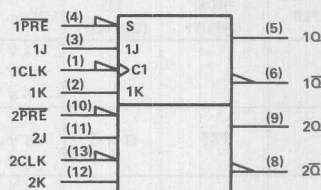


SN54HC113 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

**logic symbol**



maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC113		SN74HC113		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V		6		4.2		5	MHz
		4.5 V		31		21		25	
		6 V		36		25		29	
t <sub>w</sub>	Pulse duration	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub>	Setup time before CLK↓	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	PRE inactive	2 V	25		40		30		ns
		4.5 V	5		8		6		
		6 V	4		7		5		
t <sub>h</sub>	Hold time, data after CLK↓	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC113		SN74HC113		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	10		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		29		
t <sub>pd</sub>	PRE	Q or Q̄	2 V		60	165		250		205	ns
			4.5 V		18	33		50		41	
			6 V		15	28		43		35	
t <sub>pd</sub>	CLK	Q or Q̄	2 V		85	140		210		175	ns
			4.5 V		19	28		42		35	
			6 V		16	24		36		30	
t <sub>t</sub>		Q or Q̄	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC114, SN74HC114 DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET, COMMON CLEAR, AND COMMON CLOCK

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain two independent J-K negative-edge-triggered flip-flops. a low level at the Preset or Clear inputs sets or resets the outputs regardless of the levels of the other inputs. When the Preset and Clear are inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can perform as toggle flip-flops by tying J and K high.

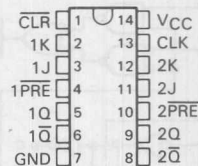
The SN54HC114 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC114 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

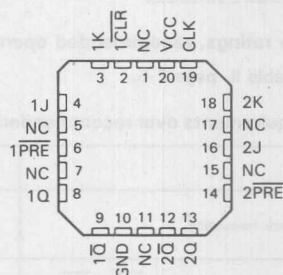
INPUTS					OUTPUTS	
PRE	CLR	CLK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	L	L	L	$Q_0$	$\bar{Q}_0$
H	H	L	H	L	H	L
H	H	L	L	H	L	H
H	H	L	H	H	TOGGLE	TOGGLE
H	H	H	X	X	$Q_0$	$\bar{Q}_0$

\* This configuration is nonstable; that is, it will not persist when either Preset or Clear returns to its inactive (high) level.

SN54HC114...J PACKAGE  
SN74HC114...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

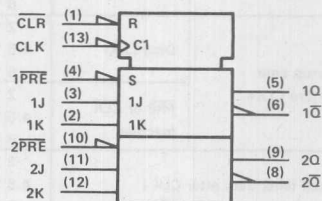


SN54HC114...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



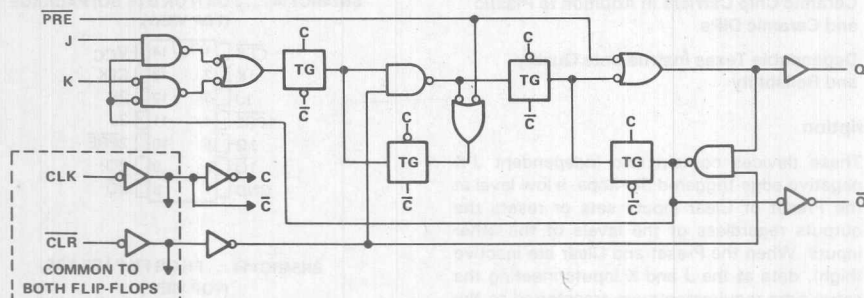
Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

**TYPES SN54HC114, SN74HC114**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS**  
**WITH PRESET, COMMON CLEAR, AND COMMON CLOCK**

logic diagram, each flip-flop (positive logic)



**3**

**HCMS DEVICES**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC114		SN74HC114		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5	0	3.3	0	4	MHz
		4.5 V	0	25	0	17	0	20	
		6 V	0	29	0	20	0	24	
t <sub>w</sub>	PRE or $\overline{\text{CLR}}$ low	2 V	100		150		125	ns	
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK high or low	2 V	100		150		125		
		4.5 V	20		30		25		
		6 V	17		25		21		
t <sub>su</sub>	Data (J,K)	2 V	100		150		125	ns	
		4.5 V	20		30		25		
		6 V	17		25		21		
	PRE or $\overline{\text{CLR}}$ inactive	2 V	100		150		125		
		4.5 V	20		30		25		
		6 V	17		25		21		
t <sub>h</sub>	Hold time, data after CLK ↓	2 V	0		0		0	ns	
		4.5 V	0		0		0		
		6 V	0		0		0		

**TYPES SN54HC114, SN74HC114**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS**  
**WITH PRESET, COMMON CLEAR, AND COMMON CLOCK**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC114		SN74HC114		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	9	3.3		4		MHz
			4.5 V	25	45	17		20		
			6 V	29	50	20		24		
t <sub>pd</sub>	$\overline{\text{PRE}}$ or $\overline{\text{CLR}}$	Q or $\overline{Q}$	2 V		75 175		250		220	ns
			4.5 V		20 35		50		44	
			6 V		17 30		42		37	
t <sub>pd</sub>	CLK	Q or $\overline{Q}$	2 V		63 175		250		220	ns
			4.5 V		19 35		50		44	
			6 V		16~ 30		42		37	
t <sub>t</sub>		Q or $\overline{Q}$	2 V		28 75		110		95	ns
			4.5 V		8 15		22		19	
			6 V		6 13		19		16	
C <sub>pd</sub>	Power dissipation capacitance			No load, T <sub>A</sub> = 25°C				50 pF typ		

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC125, SN54HC126 SN74HC125, SN74HC126 QUADRUPLE BUS BUFFER GATES WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- High-Current 3-State Outputs Interface Directly with System Bus or Can Drive Up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These bus buffers feature independent line drivers with three-state outputs. Each 'HC125 output is disabled when the associated  $\overline{G}$  is high, and each 'HC126 output is disabled when the associated G is low.

The SN54HC125 and SN54HC126 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC125 and SN74HC126 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### FUNCTION TABLES

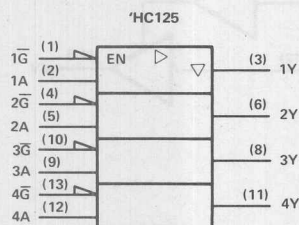
'HC125  
(EACH BUFFER)

INPUTS		OUTPUT	
$\overline{G}$	A	Y	
L	H	H	
L	L	L	
H	X	Z	

'HC126  
(EACH BUFFER)

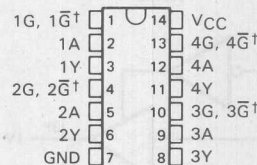
INPUTS		OUTPUT	
G	A	Y	
H	H	H	
H	L	L	
L	X	Z	

### logic symbols

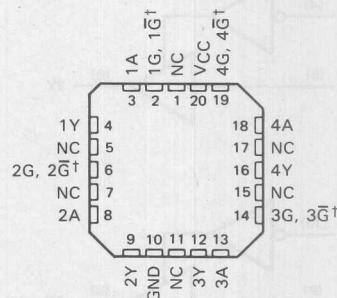


Pin numbers shown are for J and N packages.

SN54HC125, SN54HC126... J PACKAGE  
SN74HC125, SN74HC126... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

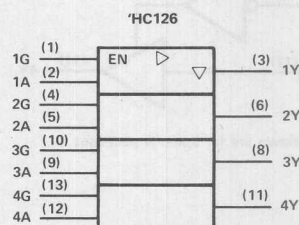


SN54HC125, SN54HC126... FH OR FK PACKAGE  
(TOP VIEW)



† $\overline{G}$  on 'HC125; G on 'HC126

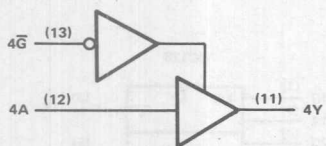
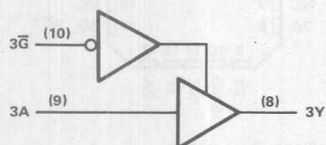
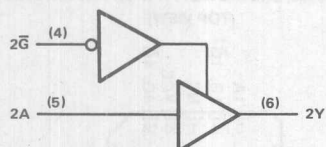
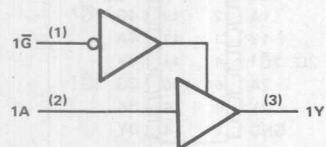
NC—No internal connection



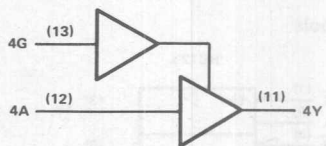
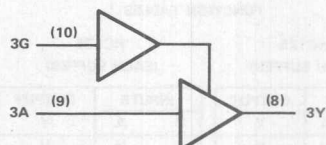
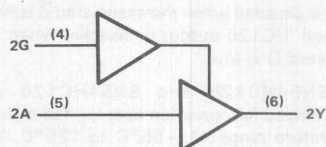
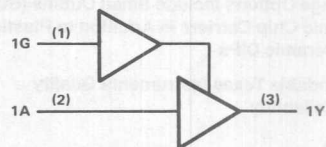
**TYPES SN54HC125, SN54HC126, SN74HC125, SN74HC126**  
**QUADRUPLE BUS BUFFER GATES WITH 3-STATE OUTPUTS**

logic diagrams (positive logic)

'HC125



'HC126



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES



# **TYPES SN54HC125, SN74HC125** **QUADRUPLER BUS BUFFER GATES WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC125		SN74HC125		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		48	120		180		150	ns
			4.5 V		14	24		36		30	
			6 V		11	20		31		26	
$t_{en}$	$\overline{G}$	Y	2 V		53	120		180		150	ns
			4.5 V		14	24		36		30	
			6 V		11	20		31		26	
$t_{dis}$	$\overline{G}$	Y	2 V		30	120		180		150	ns
			4.5 V		15	24		36		30	
			6 V		14	20		31		26	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	45 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC125		SN74HC125		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		67	150		225		190	ns
			4.5 V		19	30		45		38	
			6 V		15	25		39		32	
$t_{en}$	$\overline{G}$	Y	2 V		100	135		200		170	ns
			4.5 V		20	27		40		34	
			6 V		17	23		34		29	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**3**  
**HCMOS DEVICES**

# **TYPES SN54HC126, SN74HC126** **QUADRUPLE BUS BUFFER GATES WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC126		SN74HC126		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		47	120		180		150	ns
			4.5 V		14	24		36		30	
			6 V		11	20		31		26	
$t_{en}$	G	Y	2 V		57	120		180		150	ns
			4.5 V		16	24		36		30	
			6 V		12	20		31		26	
$t_{dis}$	G	Y	2 V		35	120		180		150	ns
			4.5 V		17	24		36		30	
			6 V		15	20		31		26	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	45 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC126		SN74HC126		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		67	150		225		188	ns
			4.5 V		19	30		45		38	
			6 V		15	25		39		33	
$t_{en}$	G	Y	2 V		100	135		202		169	ns
			4.5 V		20	27		40		36	
			6 V		17	23		36		30	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC133, SN74HC133 13-INPUT POSITIVE-NAND GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

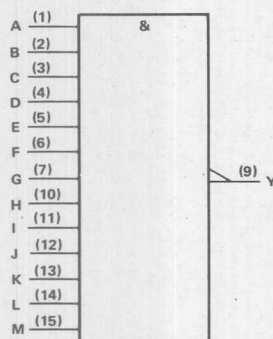
These devices contain a single 13-input NAND gate. They perform the Boolean functions in positive logic:

$$Y = \overline{A \cdot B \cdot C \cdot D \cdot E \cdot F \cdot G \cdot H \cdot I \cdot J \cdot K \cdot L \cdot M} \quad \text{or}$$

$$Y = \overline{\overline{A} + \overline{B} + \overline{C} + \overline{D} + \overline{E} + \overline{F} + \overline{G} + \overline{H} + \overline{I} + \overline{J} + \overline{K} + \overline{L} + \overline{M}}$$

The SN54HC133 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC133 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## logic symbol

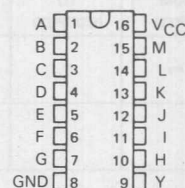


Pin numbers shown are for J and N packages.

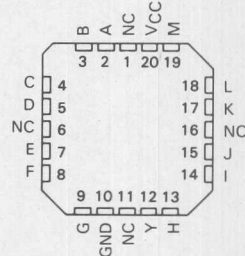
## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

## SN54HC133...J PACKAGE SN74HC133...J OR N OR D (= SO) PACKAGE (TOP VIEW)



## SN54HC133...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

## FUNCTION TABLE

INPUTS A THRU M	OUTPUT Y
All inputs H	L
One or more inputs L	H

3

HCMOS DEVICES

# **TYPES SN54HC133, SN74HC133** **13-INPUT POSITIVE-NAND GATES**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC133		SN74HC133		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any	Y	2 V		70	150		225		190	ns
			4.5 V		16	30		45		38	
			6 V		13	26		38		33	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	24 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC137, SN74HC137 3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES

D2684, DECEMBER 1982—REVISED MARCH 1984

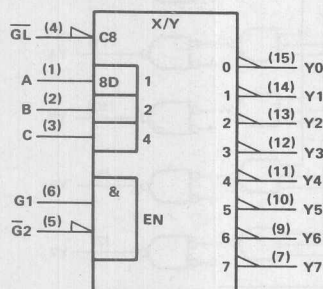
- Combines Decoder and 3-Bit Address Latch
- Incorporates 2 Output Enables to Simplify Cascading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC137 is a three-line to eight-line decoder/demultiplexer with latches on the three address inputs. When the latch-enable input ( $\overline{GL}$ ) is low, the 'HC137 acts as a decoder/demultiplexer. When  $\overline{GL}$  goes from low to high, the address present at the select inputs (A, B, and C) is stored in the latches. Further address changes are ignored as long as  $\overline{GL}$  remains high. The output enable controls, G1 and  $\overline{G2}$ , control the outputs independently of the select or latch-enable inputs. All of the outputs are forced high if G1 is low or  $\overline{G2}$  is high. The 'HC137 is ideally suited for implementing glitch-free decoders in strobed (stored-address) applications in bus-oriented systems.

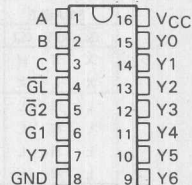
The SN54HC137 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC137 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbols (alternatives)

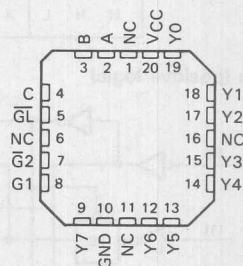


Pin numbers shown are for J and N packages.

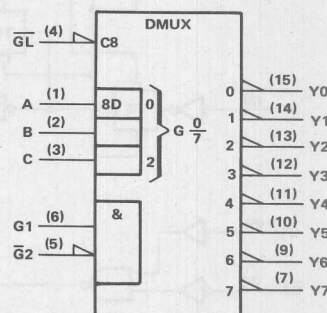
### SN54HC137... J PACKAGE SN74HC137... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC137... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection



**TYPES SN54HC137 SN74HC137**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**  
**WITH ADDRESS LATCHES**

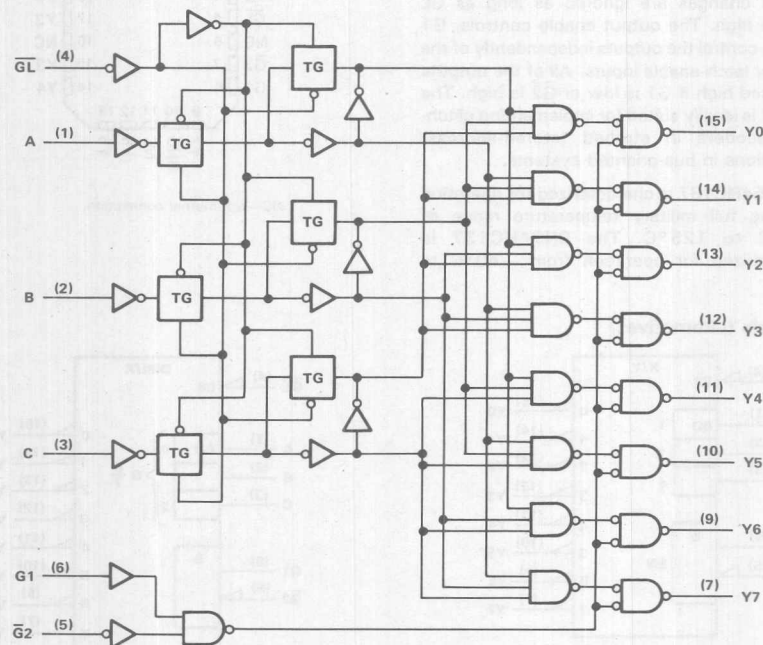
FUNCTION TABLE

INPUTS						OUTPUTS							
ENABLE			SELECT										
$\overline{G1}$	G1	$\overline{G2}$	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	H	H	H	H	H	H	H	H
X	L	X	X	X	X	H	H	H	H	H	H	H	H
L	H	L	L	L	L	L	H	H	H	H	H	H	H
L	H	L	L	L	H	H	L	H	H	H	H	H	H
L	H	L	L	H	L	H	H	L	H	H	H	H	H
L	H	L	L	H	H	H	H	L	H	H	H	H	H
L	H	L	H	L	L	H	H	H	H	L	H	H	H
L	H	L	H	L	H	H	H	H	H	L	H	H	H
L	H	L	H	H	L	H	H	H	H	H	L	H	H
L	H	L	H	H	H	H	H	H	H	H	H	L	H
H	H	L	X	X	X	Output corresponding to stored address, L; all others, H							

3

logic diagram (positive logic)

HCMOS DEVICES



Pin numbers shown are for J and N packages.



**TYPES SN54HC137, SN74HC137**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**  
**WITH ADDRESS LATCHES**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC137		SN74HC137		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>W</sub> Pulse duration, $\overline{GL}$ low	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>SU</sub> Setup time, A, B, and C before $\overline{GL}$ †	2 V	75		115		95		ns
	4.5 V	15		23		19		
	6 V	13		20		16		
t <sub>H</sub> Hold time, A, B, and C after $\overline{GL}$ †	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC137		SN74HC137		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, C	Y	2 V		82	190		285		240	ns
			4.5 V		23	38		57		48	
			6 V		19	32		48		41	
t <sub>pd</sub>	$\overline{G2}$	Y	2 V		59	145		220		180	ns
			4.5 V		17	29		44		36	
			6 V		14	25		37		31	
t <sub>pd</sub>	G1	Y	2 V		61	145		220		180	ns
			4.5 V		17	29		44		36	
			6 V		14	25		37		31	
t <sub>pd</sub>	$\overline{GL}$	Y	2 V		77	190		285		240	ns
			4.5 V		22	38		57		48	
			6 V		19	32		48		41	
t <sub>t</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT137, SN74HCT137 3-LINE TO 8-LINE DECODERS/DEMULPLEXERS WITH ADDRESS LATCHES

D2804, MARCH 1984

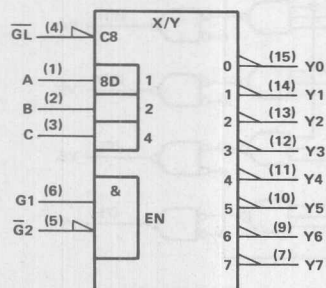
- Inputs are TTL-Voltage Compatible
- Combines Decoder and 3-Bit Address Latch
- Incorporates 2 Output Enables to Simplify Cascading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HCT137 is a three-line to eight-line decoder/demultiplexer with latches on the three address inputs. When the latch-enable input ( $\overline{GL}$ ) is low, the 'HCT137 acts as a decoder/demultiplexer. When  $\overline{GL}$  goes from low to high, the address present at the select inputs (A, B, and C) is stored in the latches. Further address changes are ignored as long as  $\overline{GL}$  remains high. The output enable controls, G1 and  $\overline{G2}$ , control the outputs independently of the select or latch-enable inputs. All of the outputs are forced high if G1 is low or  $\overline{G2}$  is high. The 'HCT137 is ideally suited for implementing glitch-free decoders in strobed (stored-address) applications in bus-oriented systems.

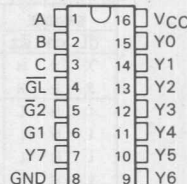
The SN54HCT137 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT137 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbols (alternatives)

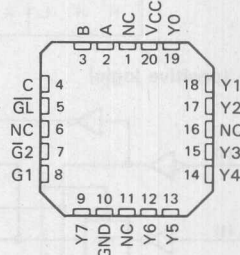


Pin numbers shown are for J and N packages.

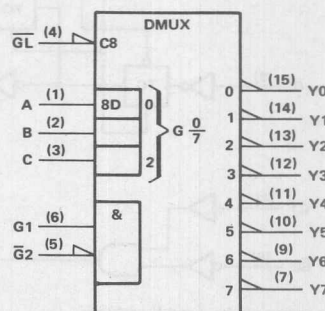
SN54HCT137 ... J PACKAGE  
SN74HCT137 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT137 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection



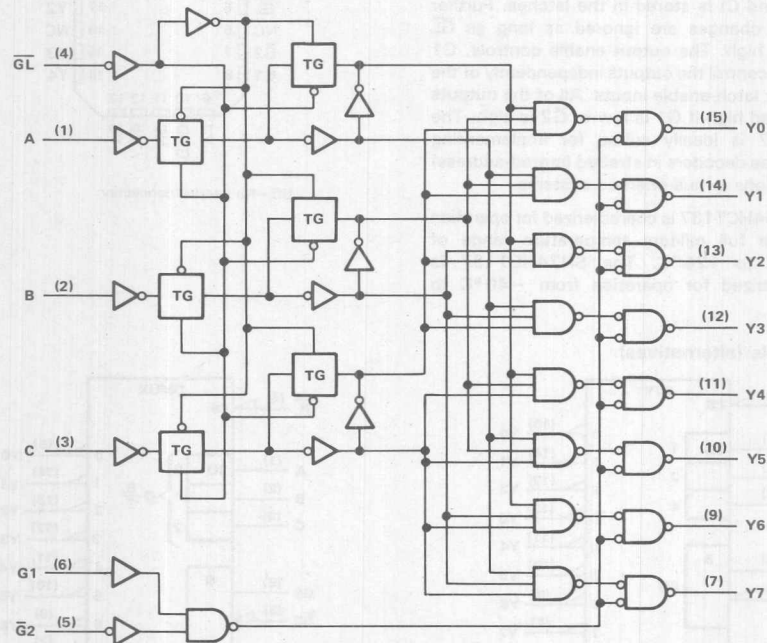
FUNCTION TABLE

INPUTS						OUTPUTS							
ENABLE			SELECT										
$\overline{G1}$	G1	$\overline{G2}$	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	H	H	H	H	H	H	H	H
X	L	X	X	X	X	H	H	H	H	H	H	H	H
L	H	L	L	L	L	L	H	H	H	H	H	H	H
L	H	L	L	L	H	H	L	H	H	H	H	H	H
L	H	L	L	H	L	H	H	L	H	H	H	H	H
L	H	L	L	H	H	H	H	L	H	H	H	H	H
L	H	L	H	L	L	H	H	H	H	L	H	H	H
L	H	L	H	L	H	H	H	H	H	H	L	H	H
L	H	L	H	H	L	H	H	H	H	H	H	L	H
L	H	L	H	H	H	H	H	H	H	H	H	H	L
H	H	L	X	X	X	Output corresponding to stored address, L; all others, H							

3

HCMOS DEVICES

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

# **TYPES SN54HCT137, SN74HCT137** **3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS** **WITH ADDRESS LATCHES**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table VIII, page 2-15.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT137		SN74HCT137		UNIT
		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, $\overline{\text{GL}}$ low	4.5 V	26			39		33		ns
	5.5 V	23			35		30		
t <sub>su</sub> Setup time, A, B, and C before $\overline{\text{GL}}$ †	4.5 V	15			23		19		ns
	5.5 V	14			21		17		
t <sub>h</sub> Hold time, A, B, and C after $\overline{\text{GL}}$ †	4.5 V	5			5		5		ns
	5.5 V	5			5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT137		SN74HCT137		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, C	Y	4.5 V		25	38		57		48	ns
			5.5 V		20	34		51		43	
t <sub>pd</sub>	$\overline{\text{G2}}$	Y	4.5 V		20	29		44		36	ns
			5.5 V		17	25		40		32	
t <sub>pd</sub>	G1	Y	4.5 V		20	29		44		36	ns
			5.5 V		17	25		40		32	
t <sub>pd</sub>	$\overline{\text{GL}}$	Y	4.5 V		32	42		63		52	ns
			5.5 V		25	36		57		47	
t <sub>t</sub>		Any	4.5 V		12	15		22		19	ns
			5.5 V		11	14		20		17	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES





## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC138, SN74HC138 3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Designed Specifically for High-Speed Memory Decoders and Data Transmission Systems
- Incorporates 3 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

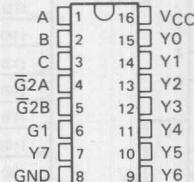
### description

The 'HC138 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast enable circuit, the delay times of this decoder and the enable time of the memory are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

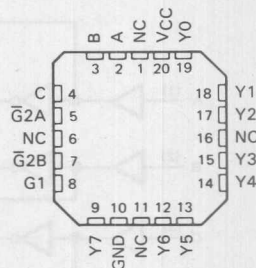
The conditions at the binary select inputs at the three enable inputs select one of eight input lines. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented without external inverters and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The SN54HC138 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC138 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC138...J PACKAGE  
SN74HC138...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC138...FH OR FK PACKAGE  
(TOP VIEW)

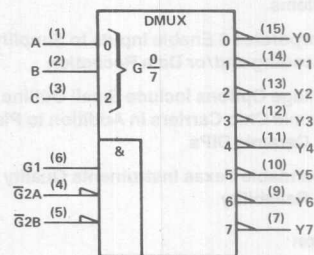
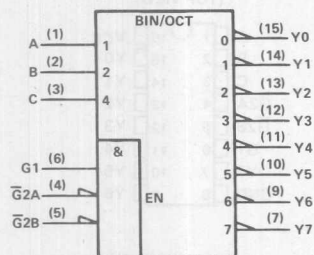


NC—No internal connection

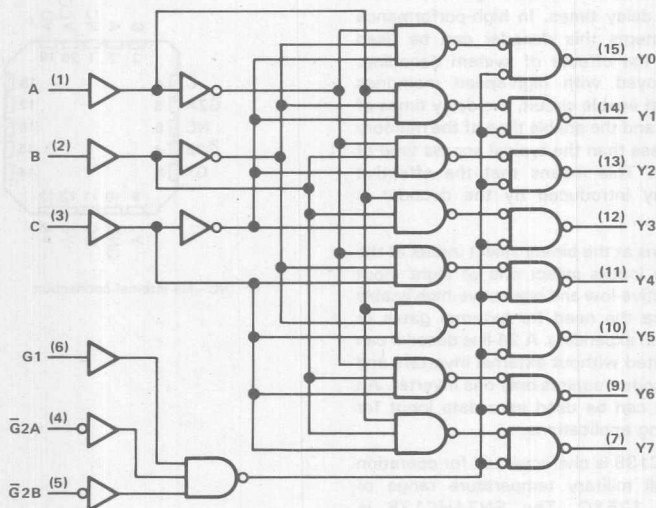
3

HC MOS DEVICES

logic symbols (alternatives)



logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**TYPES SN54HC138, SN74HC138**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

FUNCTION TABLE

ENABLE INPUTS			SELECT INPUTS			OUTPUTS							
G1	G2A	G2B	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	X	H	H	H	H	H	H	H	H
X	X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	L	L	H	H	H	H	L	H	H	H
H	L	L	H	L	H	H	H	H	H	L	H	H	H
H	L	L	H	H	L	H	H	H	H	H	L	H	H
H	L	L	H	H	H	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC138		SN74HC138		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Any Y	2 V		67	180		270		225	ns
			4.5 V		18	36		54		45	
			6 V		15	31		46		38	
$t_{pd}$	Enable	Any Y	2 V		66	155		235		195	ns
			4.5 V		18	31		47		39	
			6 V		15	26		40		33	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

FUNCTION TABLE

INPUT CODE	OUTPUT			
	A	B	C	D
000	0	0	0	0
001	0	0	1	0
010	0	1	0	0
011	0	1	1	0
100	1	0	0	0
101	1	0	1	0
110	1	1	0	0
111	1	1	1	0
000	0	0	0	1
001	0	0	1	1
010	0	1	0	1
011	0	1	1	1
100	1	0	0	1
101	1	0	1	1
110	1	1	0	1
111	1	1	1	1

Maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 3-10

Switching characteristics over recommended operating conditions (unless otherwise noted,  $C_L = 50$  pF, test level 1)

Parameter	Symbol	Units	Typical	Max	Min
Propagation delay	$t_{PD}$	ns	10	15	5
Setup time	$t_{SU}$	ns	10	15	5
Hold time	$t_{HD}$	ns	10	15	5
Output delay	$t_{OD}$	ns	10	15	5
Output rise/fall time	$t_{R}/t_{F}$	ns	10	15	5
Output current	$I_{OL}$	mA	10	15	5
Output voltage	$V_{OL}$	V	1.0	1.5	0.5
Input current	$I_{IH}$	μA	10	15	5
Input voltage	$V_{IH}$	V	1.0	1.5	0.5
Input delay	$t_{DI}$	ns	10	15	5

Power dissipation	$P_D$	W	10	15	5
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NOTE: 1. Load capacitance  $C_L$  is specified in Table IV, page 3-10

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HCMOS DEVICES

D2804, MARCH 1984

- Inputs Are TTL-Voltage Compatible
- Designed Specifically for High-Speed memory Decoders and Data Transmission Systems
- Incorporates 3 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

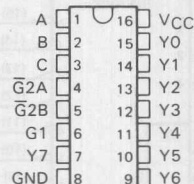
### description

The 'HCT138 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems, this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast enable circuit, the delay times of this decoder and the enable time of the memory are usually less than typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

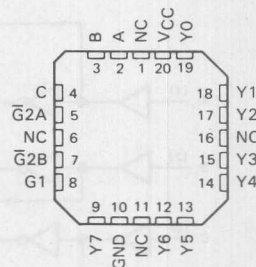
The conditions at the binary select inputs and the three enable inputs select one of eight input lines. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented without external inverters and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The SN54HCT138 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT138 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT138 ... J PACKAGE  
SN74HCT138 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT138 ... FH OR FK PACKAGE  
(TOP VIEW)



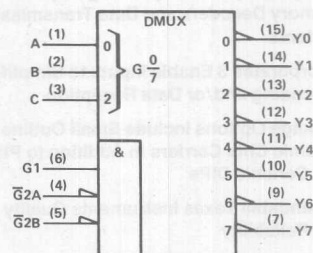
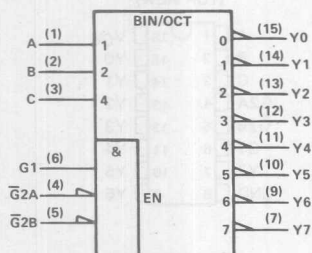
NC—No internal connection

3

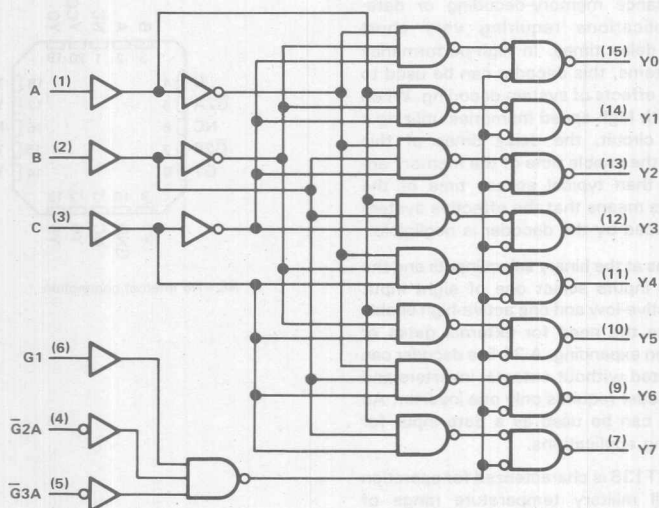
HCMOS DEVICES

# **TYPES SN54HCT138, SN74HCT138** **3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

## **logic symbols (alternatives)**



## **logic diagram (positive logic)**



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES



# TYPES SN54HCT138, SN74HCT138 3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS

FUNCTION TABLE

ENABLE INPUTS			SELECT INPUTS			OUTPUTS							
G1	G2A	G2B	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	X	H	H	H	H	H	H	H	H
X	X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	L	L	H	H	H	H	L	H	H	H
H	L	L	H	L	H	H	H	H	H	H	L	H	H
H	L	L	H	H	L	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VIII, page 2-15.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT138		SN74HCT138		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Any Y	4.5 V		23	36		54		45	ns
			5.5 V		17	32		49		34	
$t_{pd}$	Enable	Any Y	4.5 V		22	33		50		42	ns
			5.5 V		18	30		45		38	
$t_t$		Any	4.5 V		11	15		22		19	ns
			5.5 V		11	14		20		17	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

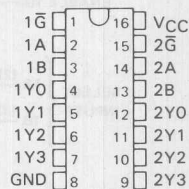
3

HCMOS DEVICES



- Designed Specifically for High-Speed Memory Decoders and Data Transmission Systems
- Incorporates 2 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC139... J PACKAGE  
SN74HC139... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



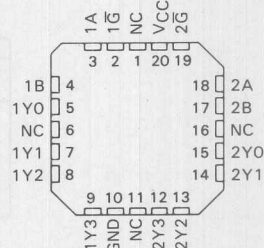
### description

The 'HC139 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems, this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast-enable circuit, the delay times of this decoder and the enable time of the memory are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

The 'HC139 is comprised of two individual two-line to four-line decoders in a single package. The active-low enable input can be used as a data line in demultiplexing applications. These decoders/demultiplexers feature fully buffered inputs, each of which represents only one normalized load to its driving circuit.

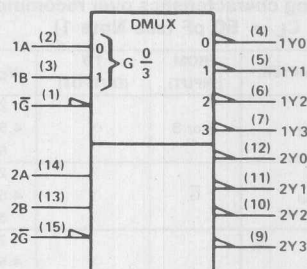
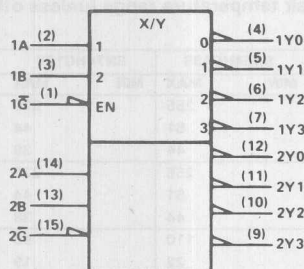
The SN54HC139 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC139 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC139... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

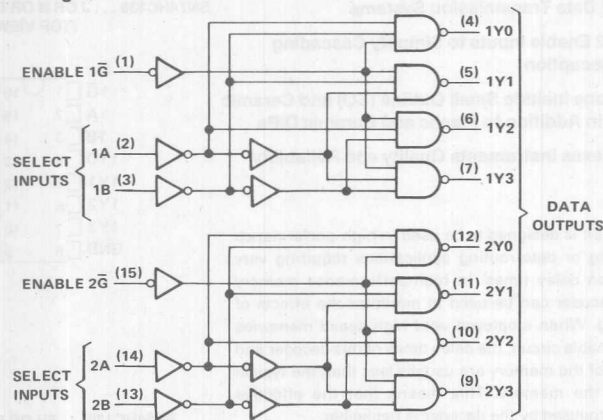
### logic symbols (alternatives)



Pin numbers shown are for J and N packages.

# TYPES SN54HC139, SN74HC139 DUAL 2-LINE TO 4-LINE DECODERS/DEMULTIPLEXERS

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

FUNCTION TABLE

INPUTS			OUTPUTS			
ENABLE	SELECT		Y0	Y1	Y2	Y3
$\bar{G}$	B	A	Y0	Y1	Y2	Y3
H	X	X	H	H	H	H
L	L	L	L	H	H	H
L	L	H	H	L	H	H
L	H	L	H	H	L	H
L	H	H	H	H	H	L

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HC139		SN74HC139		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		47	175		255		220	ns
			4.5 V		14	35		51		44	
			6 V		12	30		44		38	
$t_{pd}$	$\bar{G}$	Y	2 V		39	175		255		220	ns
			4.5 V		11	35		51		44	
			6 V		10	30		44		38	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per decoder	No load, $T_A = 25^\circ C$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**'HC147**

- Encodes 10-Line Decimal to 4-Line BCD
- Applications Include:  
Keyboard Encoding  
Range Selection

**'HC148**

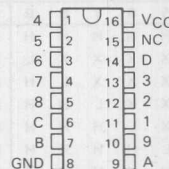
- Encodes 8 Data Lines to 3-Line Binary (Octal)
- Applications Include:  
N-Bit Encoding  
Code Converters and Generators
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

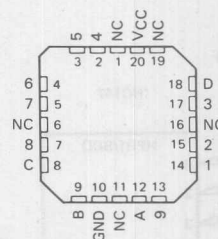
These encoders feature priority decoding of the inputs to ensure that only the highest-order data line is encoded. The 'HC147 encodes nine data lines to four-line (8-4-2-1) BCD. The implied decimal zero condition requires no input condition as zero is encoded when all nine data lines are at a high logic level. The 'HC148 encodes eight data lines to three-line (4-2-1) binary (octal). Cascading circuitry (enable input EI and enable output EO) has been provided to allow octal expansion without the need for external circuitry. For all types, data inputs and outputs are active at the low logic level.

The SN54HC147 and SN54HC148 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC147 and SN74HC148 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

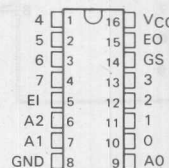
**SN54HC147 ... J PACKAGE  
SN74HC147 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



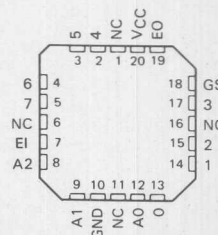
**SN54HC147 ... FH OR FK PACKAGE  
(TOP VIEW)**



**SN54HC148 ... J PACKAGE  
SN74HC148 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC148 ... FH OR FK PACKAGE  
(TOP VIEW)**



NC—No internal connection

**3**

**HCMOS DEVICES**

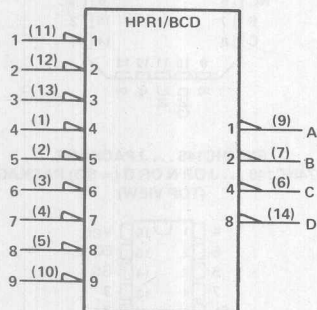
FUNCTION TABLE												
INPUTS									OUTPUTS			
1	2	3	4	5	6	7	8	9	D	C	B	A
H	H	H	H	H	H	H	H	H	H	H	H	H
X	X	X	X	X	X	X	X	L	L	H	H	L
X	X	X	X	X	X	X	L	H	L	H	H	H
X	X	X	X	X	X	L	H	H	H	L	L	L
X	X	X	X	X	L	H	H	H	H	L	L	H
X	X	X	L	H	H	H	H	H	H	L	H	H
X	X	L	H	H	H	H	H	H	H	H	L	L
L	L	H	H	H	H	H	H	H	H	H	L	H
L	H	H	H	H	H	H	H	H	H	H	H	L

FUNCTION TABLE												
INPUTS								OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	EO
H	X	X	X	X	X	X	X	X	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L
L	X	X	X	X	X	X	L	H	L	L	H	L
L	X	X	X	X	X	L	H	H	L	H	L	L
L	X	X	X	X	L	H	H	H	L	H	H	L
L	X	X	X	L	H	H	H	H	H	L	L	L
L	X	X	L	H	H	H	H	H	H	L	H	L
L	X	L	H	H	H	H	H	H	H	H	L	L
L	L	H	H	H	H	H	H	H	H	H	H	H

H = high logic level, L = low logic level, X = irrelevant

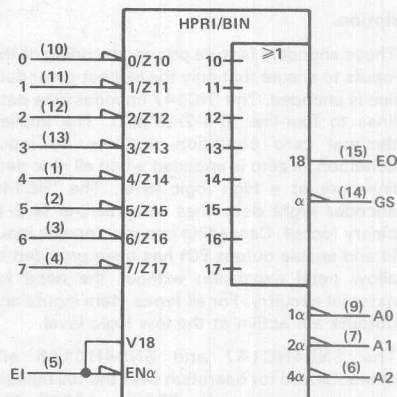
logic symbols

'HC147



Pin numbers shown are for J and N packages.

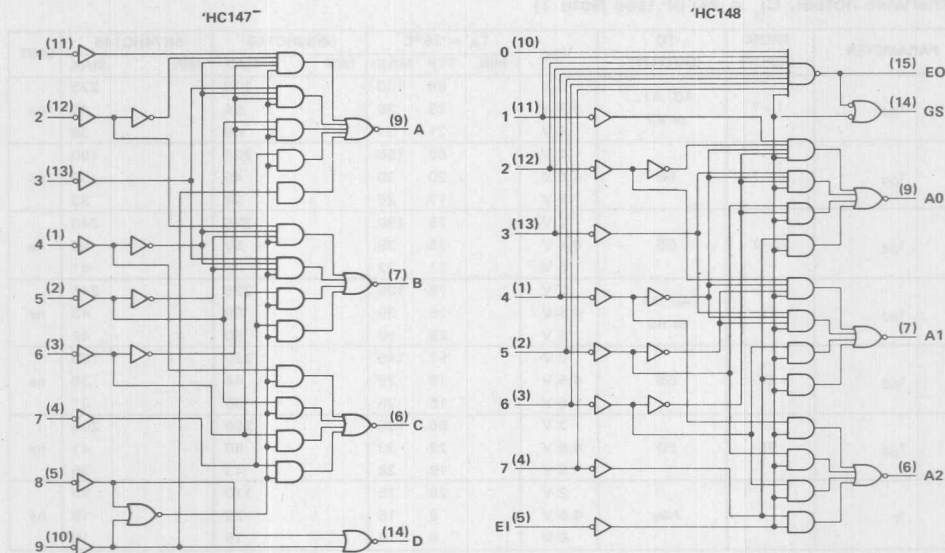
'HC148





**TYPES SN54HC147, SN54HC148  
SN74HC147, SN74HC148  
10-LINE TO 4-LINE AND 8-LINE TO 3-LINE PRIORITY ENCODERS**

**logic diagrams**



**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

'HC147 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HC147		SN74HC147		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any	Any	2 V		75	190		285		240	ns
			4.5 V		25	38		57		48	
			6 V		21	32		48		41	
$t_t$		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**TYPES SN54HC147, SN54HC148  
SN74HC147, SN74HC148  
10-LINE TO 4-LINE AND 8-LINE TO 3-LINE PRIORITY ENCODERS**

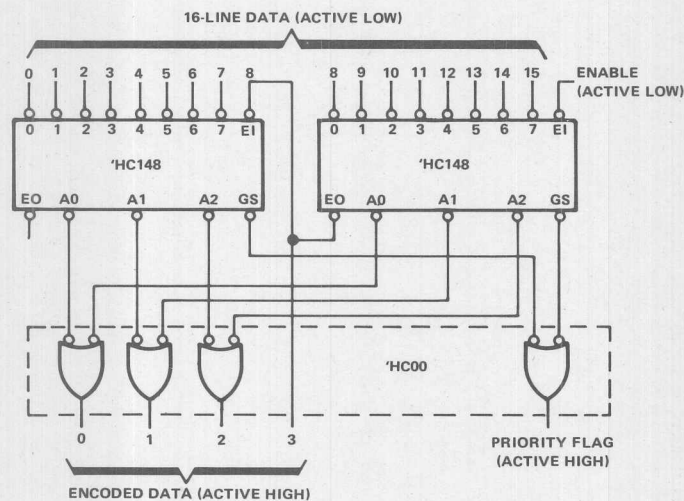
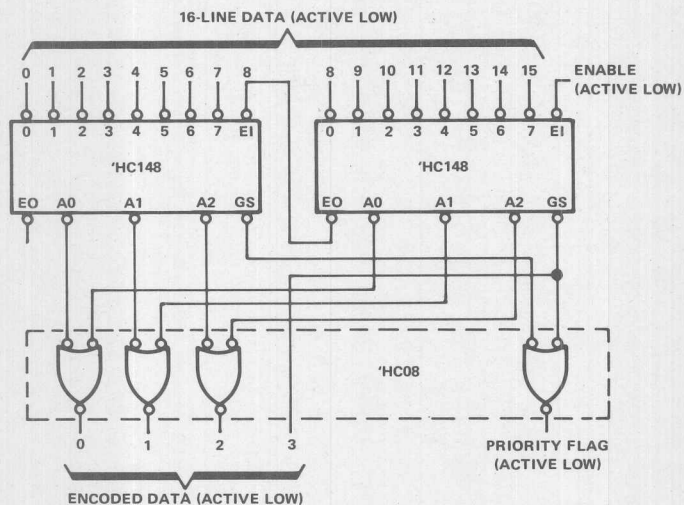
'HC148 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC148		SN74HC148		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	1-7	A0, A1, or A2	2 V		69	180		270		225	ns
			4.5 V		23	36		54		45	
			6 V		21	31		46		38	
$t_{pd}$	0-7	EO	2 V		60	150		225		190	ns
			4.5 V		20	30		45		38	
			6 V		17	26		38		33	
$t_{pd}$	0-7	GS	2 V		75	190		285		240	ns
			4.5 V		25	38		57		48	
			6 V		21	32		48		41	
$t_{pd}$	EI	A0, A1 or A2	2 V		78	195		295		245	ns
			4.5 V		26	39		59		49	
			6 V		22	33		50		42	
$t_{pd}$	EI	GS	2 V		57	145		220		180	ns
			4.5 V		19	29		44		36	
			6 V		16	25		38		31	
$t_{pd}$	EI	EO	2 V		66	165		250		205	ns
			4.5 V		22	33		50		41	
			6 V		19	28		43		35	
$t_t$		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**TYPES SN54HC147, SN54HC148  
SN74HC147, SN74HC148**  
**10-LINE TO 4-LINE AND 8-LINE TO 3-LINE PRIORITY ENCODERS**

**TYPICAL APPLICATION DATA**



**PRIORITY ENCODER FOR 16 BITS**

Since the 'HC147 and 'HC148 are combinational logic circuits, wrong addresses can appear during input transients. Moreover, for the 'HC148, a change from high to low at input EI can cause a transient low on the GS output when all inputs are high. This must be considered when strobing the outputs.



- 8-Line to 1-Line Multiplexers Can Perform As:  
Boolean Function Generators  
Parallel-to-Serial Converters  
Data Source Selectors

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

- Dependable Texas Instruments Quality and Reliability

### description

These monolithic data selectors/multiplexers provide full binary decoding to select one of eight data sources. The strobe input ( $\bar{G}$ ) must be at a low logic level to enable the inputs. A high level at the strobe terminal forces the W output high and the Y output low.

The SN54HC151 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC151 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

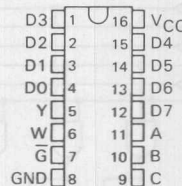
FUNCTION TABLE

INPUTS			STROBE $\bar{G}$	OUTPUTS	
SELECT C	B	A		Y	W
X	X	X	H	L	H
L	L	L	L	D0	$\bar{D}0$
L	L	H	L	D1	$\bar{D}1$
L	H	L	L	D2	$\bar{D}2$
L	H	H	L	D3	$\bar{D}3$
H	L	L	L	D4	$\bar{D}4$
H	L	H	L	D5	$\bar{D}5$
H	H	L	L	D6	$\bar{D}6$
H	H	H	L	D7	$\bar{D}7$

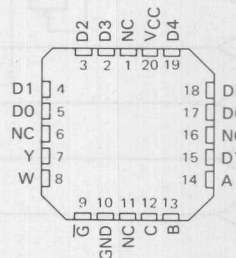
H = high level, L = low level, X = irrelevant

D0, D1 . . . D7 = the level of the D respective input

SN54HC151 . . . J PACKAGE  
SN74HC151 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

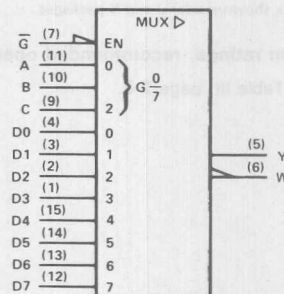


SN54HC151 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

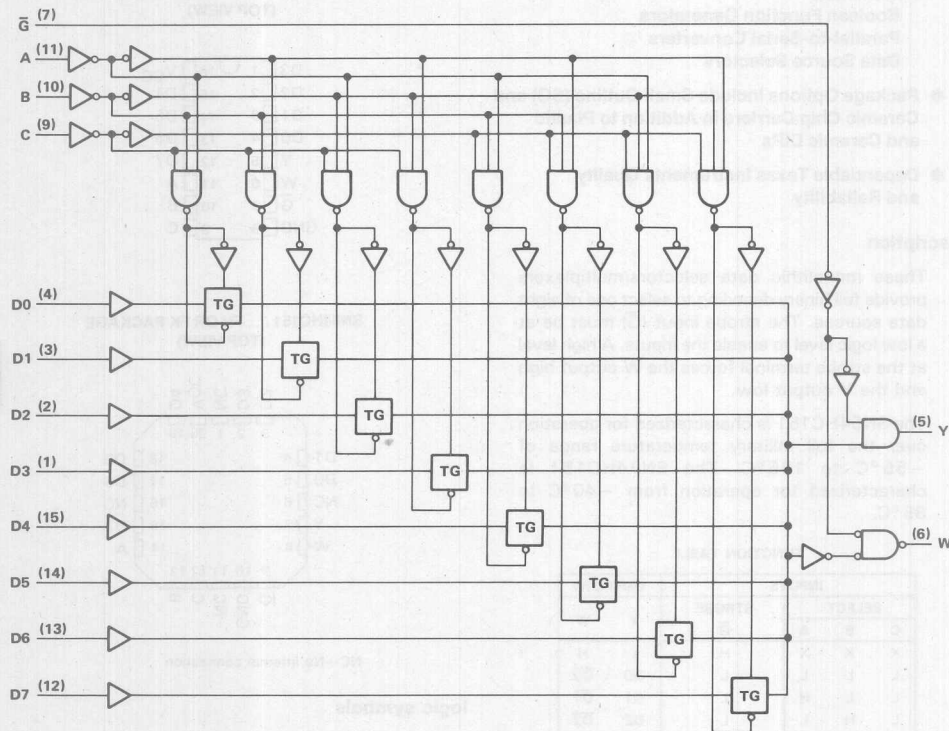
### logic symbols



Pin numbers shown are for J and N packages

# **TYPES SN54HC151, SN74HC151** **8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

3  
 HCMOS DEVICES



# TYPES SN54HC151, SN74HC151 8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC151		SN74HC151		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Y or W	2 V		94	250		360		312	ns
			4.5 V		30	50		73		63	
			6 V		25	43		62		54	
$t_{pd}$	Any D	Y or W	2 V		74	195		283		244	ns
			4.5 V		23	39		57		49	
			6 V		20	33		48		41	
$t_{pd}$	$\bar{G}$	Y or W	2 V		49	127		185		159	ns
			4.5 V		15	25		37		32	
			6 V		13	22		32		28	
$t_t$			2 V		22	75		110		95	ns
			4.5 V		9	15		22		19	
			6 V		8	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	70 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC151		SN74HC151		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Y or W	2 V		107	350		525		440	ns
			4.5 V		33	70		105		88	
			6 V		30	59		89		76	
$t_{pd}$	Any D	Y or W	2 V		90	275		415		345	ns
			4.5 V		29	51		83		69	
			6 V		25	47		72		59	
$t_{pd}$	$\bar{G}$	Y or W	2 V		67	205		310		255	ns
			4.5 V		21	41		62		51	
			6 V		18	35		53		43	
$t_t$			2 V		51	210		315		265	ns
			4.5 V		16	42		63		53	
			6 V		14	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

Switching characteristics given recommended operating conditions and temperature range unless otherwise noted.  $C_L = 50$  pF (see Note 1)

PARAMETER	SYMBOL	UNIT	TEST CONDITIONS	TA = 25°C				TYP
				MAX	MIN	MAX	MIN	
Propagation delay	$t_{PLH}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Falling delay	$t_{PLL}$	ns	V <sub>OH</sub> to V <sub>OL</sub>	100	50	100	50	75
				100	50	100	50	75
Settling time	$t_{SPL}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Rise time	$t_{RPL}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Falling time	$t_{FPL}$	ns	V <sub>OH</sub> to V <sub>OL</sub>	100	50	100	50	75
				100	50	100	50	75

Power dissipation: 100 mW, TA = 25°C

Switching characteristics given recommended operating conditions and temperature range unless otherwise noted.  $C_L = 100$  pF (see Note 1)

PARAMETER	SYMBOL	UNIT	TEST CONDITIONS	TA = 25°C				TYP
				MAX	MIN	MAX	MIN	
Propagation delay	$t_{PLH}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Falling delay	$t_{PLL}$	ns	V <sub>OH</sub> to V <sub>OL</sub>	100	50	100	50	75
				100	50	100	50	75
Settling time	$t_{SPL}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Rise time	$t_{RPL}$	ns	V <sub>OL</sub> to V <sub>OH</sub>	100	50	100	50	75
				100	50	100	50	75
Falling time	$t_{FPL}$	ns	V <sub>OH</sub> to V <sub>OL</sub>	100	50	100	50	75
				100	50	100	50	75

NOTE 1: For test results with other conditions, see page 102.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC152, SN74HC152 8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Selects One-of-Eight Data Sources
- Performs Parallel-to-Serial Conversion
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

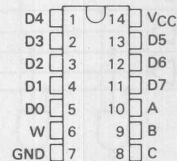
These monolithic data selectors/multiplexers contain full on-chip binary decoding to select the desired one-of-eight data sources.

The SN54HC152 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC152 is characterized for operation from -40°C to 85°C.

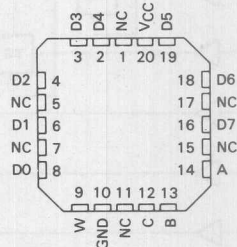
FUNCTION TABLE

SELECT INPUTS			OUTPUT W
C	B	A	
L	L	L	$\overline{D0}$
L	L	H	$\overline{D1}$
L	H	L	$\overline{D2}$
L	H	H	$\overline{D3}$
H	L	L	$\overline{D4}$
H	L	H	$\overline{D5}$
H	H	L	$\overline{D6}$
H	H	H	$\overline{D7}$

SN54HC152... J PACKAGE  
SN74HC152... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

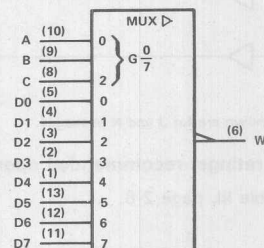


SN54HC152... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



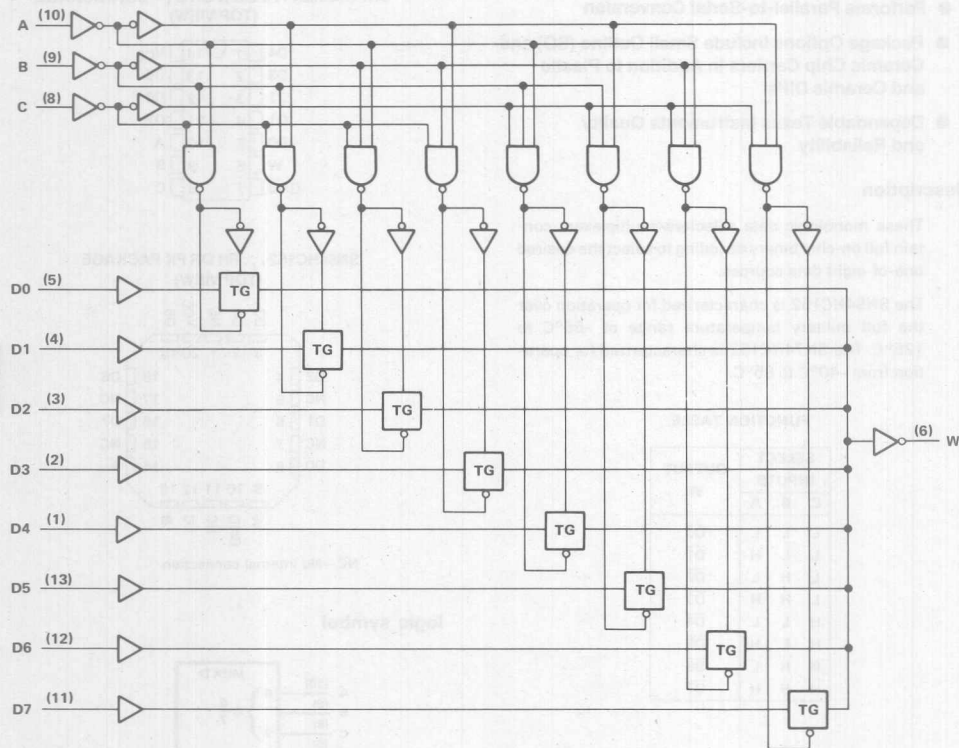
Pin numbers shown are for J and N packages.

3

HC MOS DEVICES

**TYPES SN54HC152, SN74HC152**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

# TYPES SN54HC152, SN74HC152 8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC152		SN74HC152		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	W	2 V		50	170		255		213	ns
			4.5 V		18	34		51		43	
			6 V		16	29		44		36	
$t_{pd}$	Any D	W	2 V		38	130		195		163	ns
			4.5 V		14	26		39		33	
			6 V		12	22		33		28	
$t_t$		W	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	70 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC152		SN74HC152		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	W	2 V		63	225		385		318	ns
			4.5 V		22	51		77		64	
			6 V		19	44		66		55	
$t_{pd}$	Any D	W	2 V		52	215		325		268	ns
			4.5 V		18	43		65		54	
			6 V		16	37		55		47	
$t_t$		W	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES

### 3 HCMOS DEVICES

TABLE 1. HCMOS Device Characteristics (Typical Values at  $T_A = 25^\circ\text{C}$ )

Parameter	Symbol	Unit	Typical Value	Max. Value	Min. Value
Supply Current	$I_{CC}$	mA	1.0	1.5	0.5
Input Current	$I_{in}$	mA	1.0	1.5	0.5
Output Current	$I_{out}$	mA	1.0	1.5	0.5
Propagation Delay	$t_{pd}$	ns	1.0	1.5	0.5
Settling Time	$t_{s}$	ns	1.0	1.5	0.5
Power Dissipation	$P_D$	mW	1.0	1.5	0.5

NOTE: 1. The HCMOS device is designed to operate at  $T_A = 25^\circ\text{C}$ .

TABLE 2. HCMOS Device Characteristics (Typical Values at  $T_A = 25^\circ\text{C}$ )

Parameter	Symbol	Unit	Typical Value	Max. Value	Min. Value
Supply Current	$I_{CC}$	mA	1.0	1.5	0.5
Input Current	$I_{in}$	mA	1.0	1.5	0.5
Output Current	$I_{out}$	mA	1.0	1.5	0.5
Propagation Delay	$t_{pd}$	ns	1.0	1.5	0.5
Settling Time	$t_{s}$	ns	1.0	1.5	0.5
Power Dissipation	$P_D$	mW	1.0	1.5	0.5

NOTE: 2. The HCMOS device is designed to operate at  $T_A = 25^\circ\text{C}$ .



- Permits Multiplexing from N Lines to 1 Line
- Performs Parallel-to-Serial Conversion
- Strobe (Enable) Line Provided for Cascading (N lines to n lines)
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

Each of these data selectors/multiplexers contains inverters and drivers to supply full binary decoding data selection to the AND-OR gates. Separate strobe inputs ( $\bar{G}$ ) are provided for each of the two four-line sections.

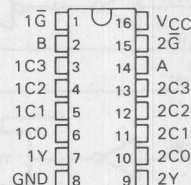
The SN54HC153 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC153 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

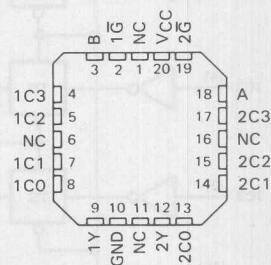
SELECT INPUTS		DATA INPUTS				STROBE	OUTPUT
B	A	C0	C1	C2	C3	$\bar{G}$	Y
X	X	X	X	X	X	H	L
L	L	L	X	X	X	L	L
L	L	L	H	X	X	L	H
L	H	X	L	X	X	L	L
L	H	X	H	X	X	L	H
H	L	X	X	L	X	L	L
H	L	X	X	H	X	L	H
H	H	X	X	X	L	L	L
H	H	X	X	X	H	L	H

Select inputs A and B are common to both sections.

SN54HC153... J PACKAGE  
SN74HC153... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

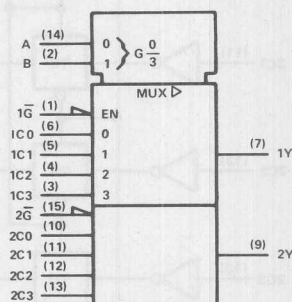


SN54HC153... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



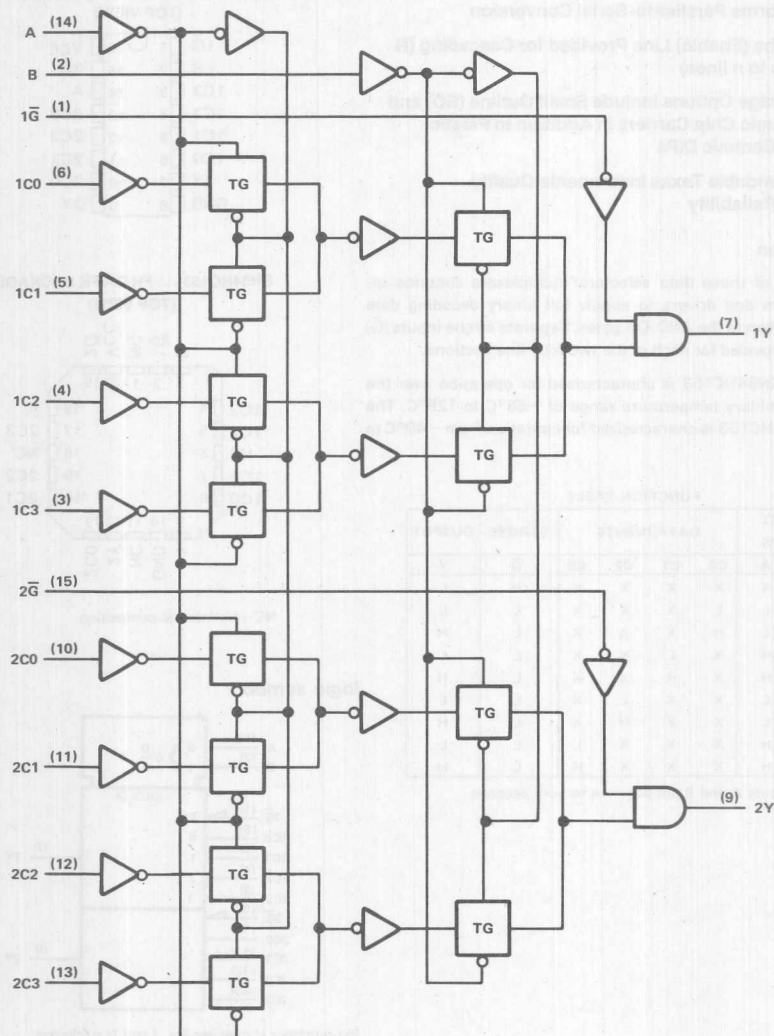
Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

**TYPES SN54HC153, SN74HC153**  
**DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

# TYPES SN54HC153, SN74HC153 DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC153		SN74HC153		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		90	150		225		190	ns
			4.5 V		21	30		45		38	
			6 V		17	26		38		32	
$t_{pd}$	Data (Any C)	Y	2 V		73	126		189		158	ns
			4.5 V		17	28		42		35	
			6 V		14	23		35		29	
$t_{pd}$	— G	Y	2 V		38	95		150		125	ns
			4.5 V		11	19		28		24	
			6 V		9	16		24		20	
$t_t$		Y	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per multiplexer	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC153		SN74HC153		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		105	235		355		295	ns
			4.5 V		27	47		71		59	
			6 V		21	41		60		51	
$t_{pd}$	Data (Any C)	Y	2 V		93	220		335		274	ns
			4.5 V		23	44		67		55	
			6 V		19	38		57		48	
$t_{pd}$	— G	Y	2 V		60	185		280		230	ns
			4.5 V		17	37		56		46	
			6 V		14	32		48		40	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# QUAL-ALINE TO LINE DATA SELECTION CHARACTERISTICS

Switching characteristics over recommended operating free-air temperature range (unless otherwise noted):  $C_J = 50$  pF (see Note 1)

UNIT	RANGE		MINIMUM		TYPICAL		V <sub>OL</sub>	V <sub>OH</sub>	I <sub>OL</sub>	I <sub>OH</sub>	T <sub>A</sub>	PARAMETER
	MIN	MAX	MIN	MAX	MIN	MAX						
ns	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
ns	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
ns	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
ns	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-55	t <sub>PLH</sub>

NOTE 1: The test circuit and signal waveforms are shown in Figure 1-1.

Switching characteristics over recommended operating free-air temperature range (unless otherwise noted):  $C_J = 150$  pF (see Note 1)

TEST	SET-UP			SET-UP			V <sub>OL</sub> - V <sub>OL</sub>		V <sub>OL</sub>	V <sub>OL</sub>	V <sub>OL</sub>	V <sub>OL</sub>	V <sub>OL</sub>
	RAM	RAM	RAM	RAM	RAM	RAM							
1	00	00	00	00	00	00	00	00	00	00	00	00	00
	01	01	01	01	01	01	01	01	01	01	01	01	01
	02	02	02	02	02	02	02	02	02	02	02	02	02
2	01	01	01	01	01	01	01	01	01	01	01	01	01
	02	02	02	02	02	02	02	02	02	02	02	02	02
	03	03	03	03	03	03	03	03	03	03	03	03	03
3	02	02	02	02	02	02	02	02	02	02	02	02	02
	03	03	03	03	03	03	03	03	03	03	03	03	03
	04	04	04	04	04	04	04	04	04	04	04	04	04
4	03	03	03	03	03	03	03	03	03	03	03	03	03
	04	04	04	04	04	04	04	04	04	04	04	04	04
	05	05	05	05	05	05	05	05	05	05	05	05	05

NOTE 1: The test circuit and signal waveforms are shown in Figure 1-1.

## 3 HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC157, SN54HC158, SN74HC157, SN74HC158 QUADRUPLE 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

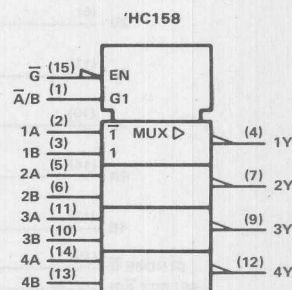
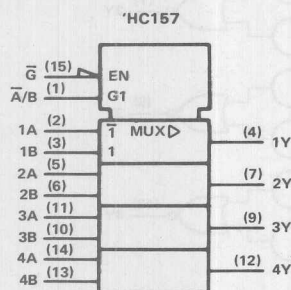
These monolithic data selectors/multiplexers contain inverters and drivers to supply full data selection to the four output gates. A separate strobe input ( $\bar{G}$ ) is provided. A 4-bit word is selected from one of two sources and is routed to the four outputs. The 'HC157 presents true data whereas the 'HC158 presents inverted data.

The SN54HC157 and SN54HC158 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC157 and SN74HC158 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

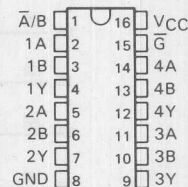
INPUTS		DATA		OUTPUT Y	
STROBE $\bar{G}$	SELECT $\bar{A}/\bar{B}$	A	B	'HC157	'HC158
H	X	X	X	L	H
L	L	L	X	L	H
L	L	H	X	H	L
L	H	X	L	L	H
L	H	X	H	H	L

### logic symbols

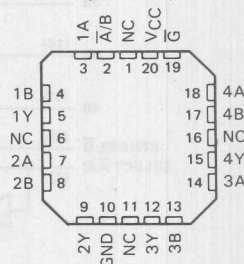


Pin numbers shown are for J and N packages.

SN54HC157, SN54HC158... J PACKAGE  
SN74HC157, SN74HC158... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC157, SN54HC158... FH OR FK PACKAGE  
(TOP VIEW)



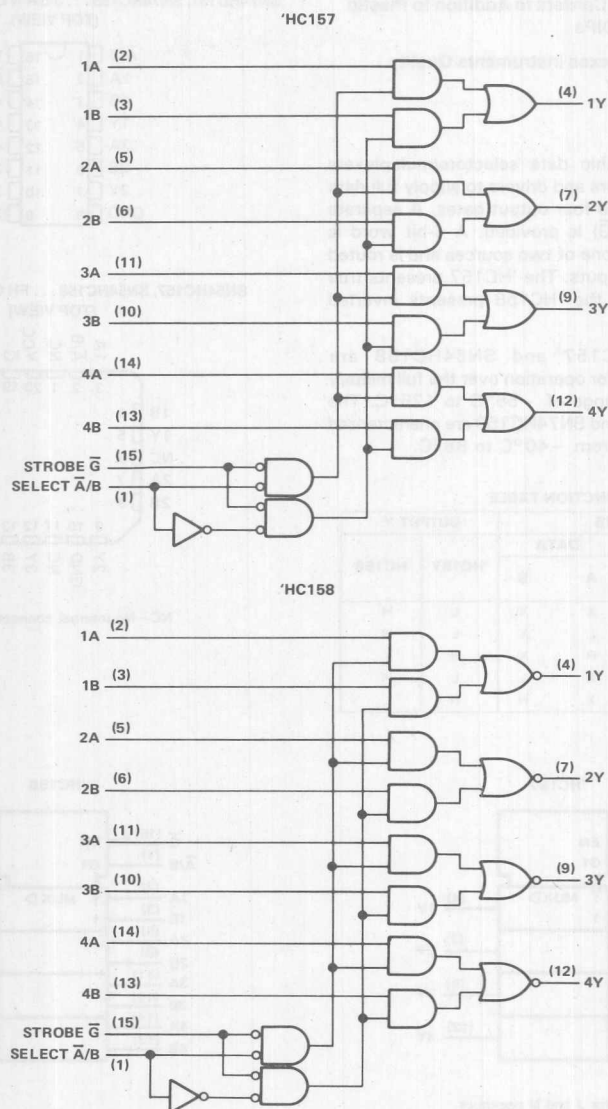
NC—No internal connection

3

HCMOS DEVICES

**TYPES SN54HC157, SN54HC158, SN74HC157, SN74HC158**  
**QUADRUPL 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

logic diagrams (positive logic)



Pin numbers shown are for J and N packages.



# **TYPES SN54HC157, SN54HC158, SN74HC157, SN74HC158** **QUADRUPL 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC157 SN54HC158		SN74HC157 SN74HC158		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		63	125		190		160	ns
			4.5 V		13	25		38		32	
			6 V		11	21		32		27	
t <sub>pd</sub>	$\bar{A}/B$	Y	2 V		67	125		190		160	ns
			4.5 V		18	25		38		31	
			6 V		14	21		32		27	
t <sub>pd</sub>	$\bar{G}$	Y	2 V		59	115		170		145	ns
			4.5 V		16	23		34		29	
			6 V		13	20		29		25	
t <sub>t</sub>		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC157 SN54HC158		SN74HC157 SN74HC158		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		81	190		290		235	ns
			4.5 V		23	38		58		47	
			6 V		18	33		49		41	
t <sub>pd</sub>	$\bar{A}/B$	Y	2 V		81	210		320		260	ns
			4.5 V		23	42		64		52	
			6 V		18	36		54		45	
t <sub>pd</sub>	$\bar{G}$	Y	2 V		91	190		290		235	ns
			4.5 V		24	38		58		47	
			6 V		18	33		49		41	
t <sub>t</sub>		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES



- Internal Look Ahead for Fast Counting
- Carry Output for N-Bit Cascading
- Synchronous Counting
- Synchronously Programmable
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These synchronous, presettable counters feature an internal carry look-ahead for application in high-speed counting designs. The 'HC160 and 'HC162 are decade counters, and the 'HC161 and 'HC163 are 4-bit binary counters. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the count-enable inputs and internal gating. This mode of operation eliminates the output counting spikes that are normally associated with synchronous (ripple clock) counters. A buffered clock input triggers the four flip-flops on the rising (positive-going) edge of the clock input waveform.

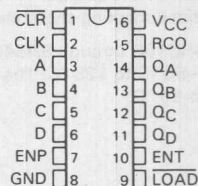
These counters are fully programmable; that is, the outputs may be preset to either level. As presetting is synchronous, setting up a low level at the load input disables the counter and causes the outputs to agree with the setup data after the next clock pulse regardless of the levels of the enable inputs.

The clear function for the 'HC160 and 'HC161 is asynchronous and a low level at the clear input sets all four of the flip-flop outputs low regardless of the levels of the clock, load, or enable inputs.

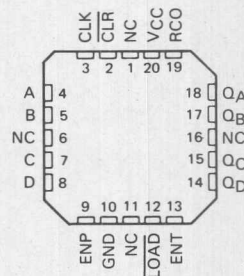
The clear function for the 'HC162 and 'HC163 is synchronous and a low level at the clear input sets all four of the flip-flop outputs low after the next low-to-high transition of the clock input, regardless of the levels of the enable inputs. This synchronous clear allows the count length to be modified easily as decoding the maximum count desired can be accomplished with one external NAND gate. The gate output is connected to the clear input to synchronously clear the counter to 0000 (LLLL).

The carry look-ahead circuitry provides for cascading counters for n-bits synchronous applications without additional gating. Instrumental in accomplishing this function are two count-enable inputs and a ripple carry output. Both count-enable inputs (ENP and ENT) must be high to count, and ENT is fed forward to enable the ripple carry output. The ripple carry output (RCO) thus enabled will produce a high-level pulse while the count is maximum (9 or 15 with  $Q_A$  high). This high-level overflow ripple carry pulse can be used to enable successive cascaded stages. Transitions at the ENP or ENT are allowed regardless of the level of the clock input.

SN54HC'... J PACKAGE  
SN74HC'... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC'... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES

# **TYPES SN54HC160 THRU SN54HC163 SN74HC160 THRU SN74HC163 SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

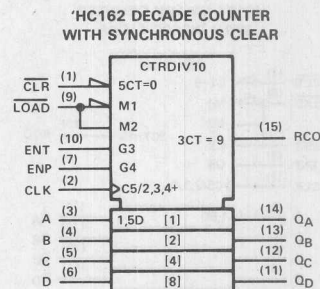
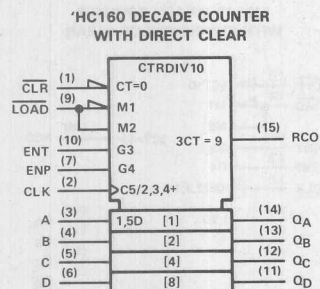
These counters feature a fully independent clock circuit. Changes at control inputs (ENP, ENT, or  $\overline{\text{LOAD}}$ ) that will modify the operating mode have no effect on the contents of the counter until clocking occurs. The function of the counter (whether enabled, disabled, loading, or counting) will be dictated solely by the conditions meeting the stable setup and hold times.

The SN54HC160 through SN54HC163 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC160 through SN74HC163 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

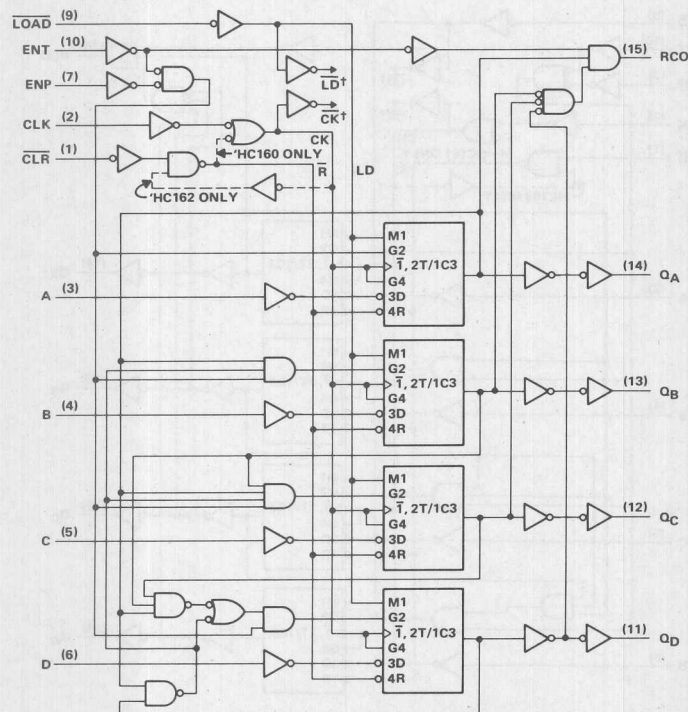


**TYPES SN54HC160, SN54HC162  
SN74HC160, SN74HC162  
SYNCHRONOUS 4-BIT DECADE COUNTERS**

**logic symbols**



**'HC160 and 'HC162 logic diagram (positive logic)**

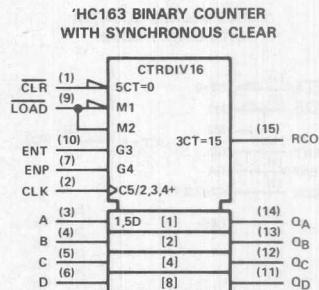
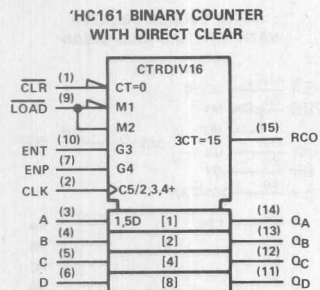


† For the sake of simplicity, the routing of the complementary signals  $\overline{LD}$  and  $\overline{CK}$  is not shown on this overall logic diagram. The uses of these signals are shown on the logic diagram of the D/T flip-flops.

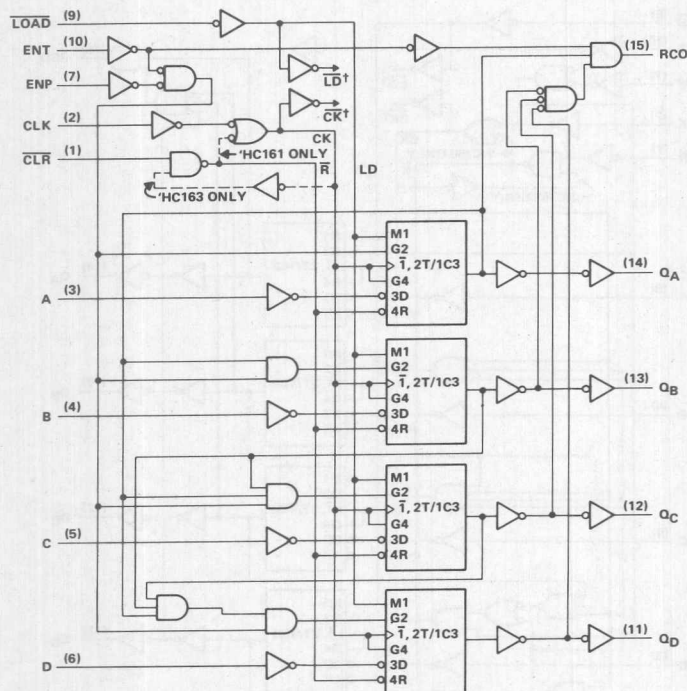
Pin numbers shown are for J and N packages.

**TYPES SN54HC161, SN54HC163  
SN74HC161, SN74HC163  
SYNCHRONOUS 4-BIT BINARY COUNTERS**

**logic symbols**



**'HC161 and 'HC163 logic diagram (positive logic)**



† For the sake of simplicity, the routing of the complementary signals  $\overline{LD}$  and  $\overline{CK}$  is not shown on this overall logic diagram. The uses of these signals are shown on the logic diagram of the D/T flip-flops.

Pin numbers shown are for J and N packages.

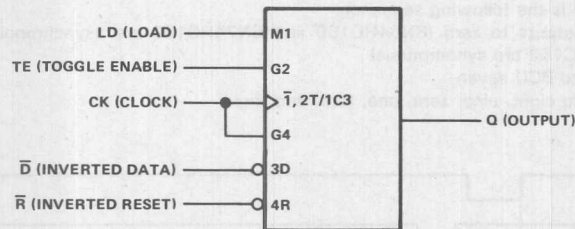
**3**

**HCMOS DEVICES**

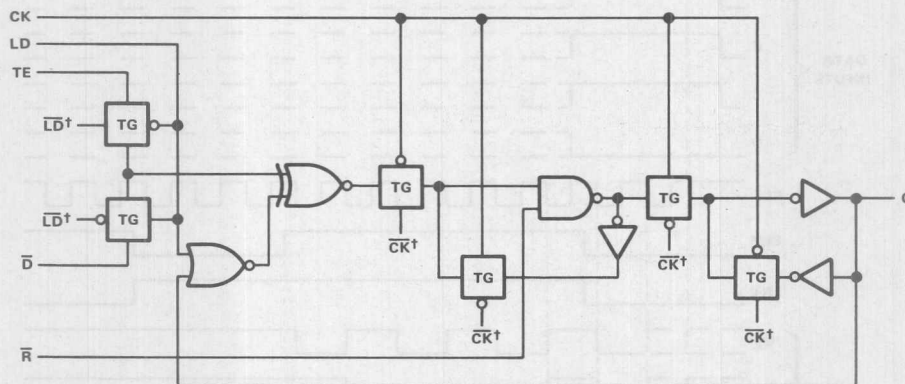


**TYPES SN54HC160 THRU SN54HC163  
SN74HC160 THRU SN74HC163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

logic symbol, each D/T flip-flop (positive logic)



logic diagram, each D/T flip-flop (positive logic)



†The origins of the signals  $\overline{LD}$  and  $\overline{CK}$  are shown in the logic diagrams of the overall devices.

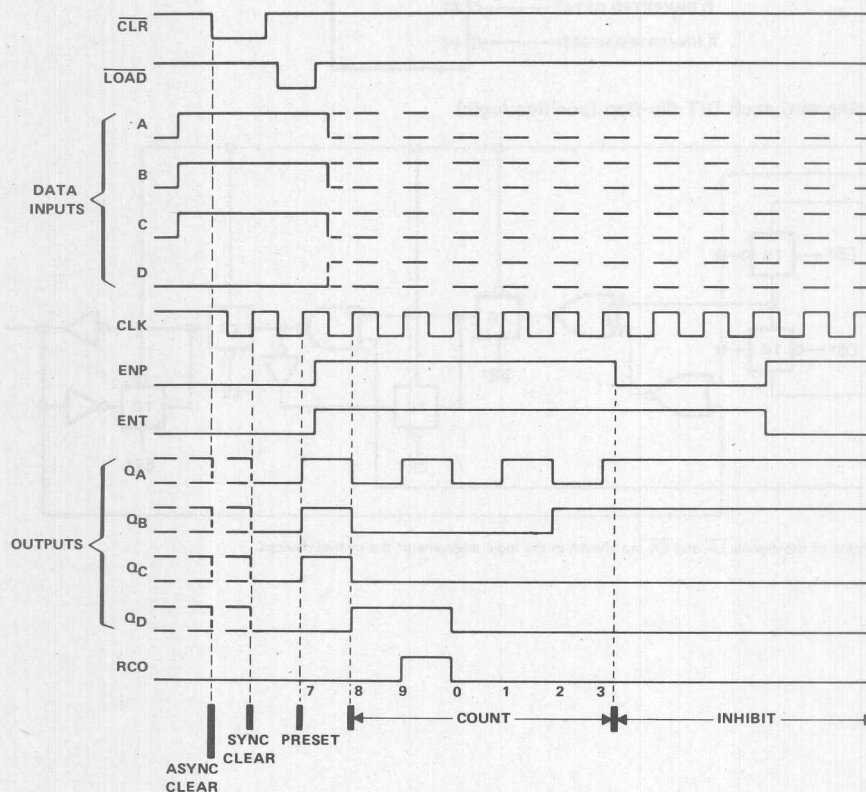
3

HCMOS DEVICES

**'HC160 and 'HC162 output sequence**

Illustrated below is the following sequence:

1. Clear outputs to zero (SN54HC160 and SN74HC160 are asynchronous; SN54HC162 and SN74HC162 are synchronous)
2. Preset to BCD seven
3. Count to eight, nine, zero, one, two, and three
4. Inhibit

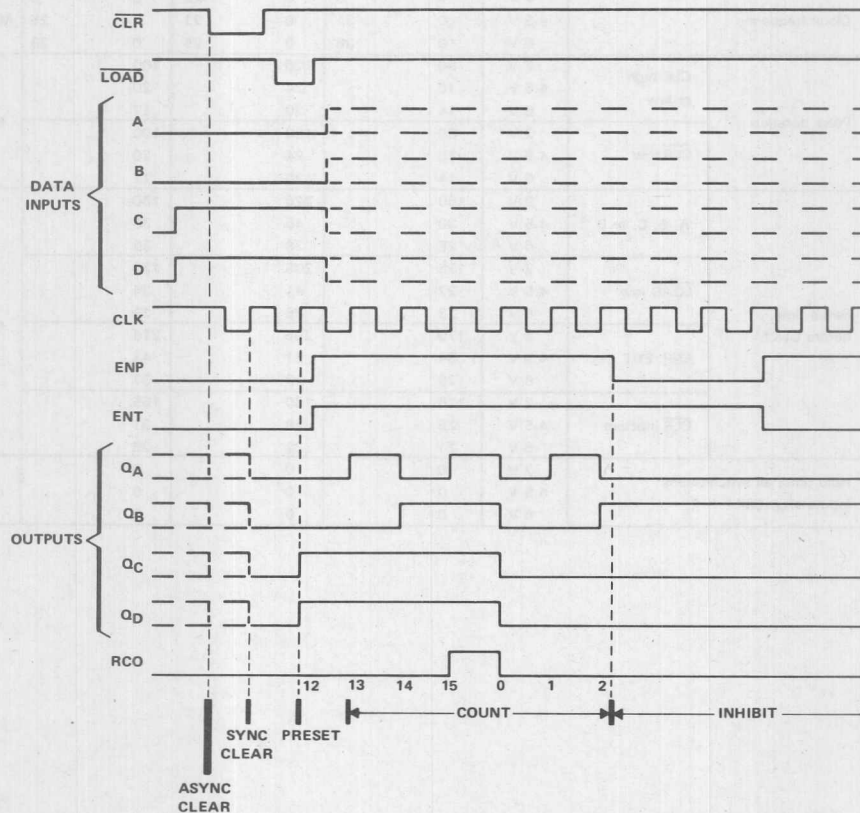


**TYPES SN54HC161, SN54HC163  
SN74HC161, SN74HC163  
SYNCHRONOUS 4-BIT BINARY COUNTERS**

**'HC161 and 'HC163 output sequence**

Illustrated below is the following sequence:

1. Clear outputs to zero (SN54HC161 and SN74HC161 are asynchronous; SN54HC163 and SN74HC163 are synchronous)
2. Preset to binary twelve
3. Count to thirteen, fourteen, zero, one, and two
4. Inhibit



**3**

**HCMOS DEVICES**

**TYPES SN54HC160, SN54HC161  
SN74HC160, SN74HC161  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC160 SN54HC161		SN74HC160 SN74HC161		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency		2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub> Pulse duration	CLK high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
	CLR low	2 V	80		120		100		
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub> Setup time, before CLK ↑	A, B, C, or D	2 V	150		225		190		ns
		4.5 V	30		45		38		
		6 V	26		38		32		
	LOAD low	2 V	135		205		170		
		4.5 V	27		41		34		
		6 V	23		35		29		
	ENP, ENT	2 V	170		255		215		
		4.5 V	34		51		43		
		6 V	29		43		37		
	CLR inactive	2 V	125		190		155		
		4.5 V	25		38		31		
		6 V	21		32		26		
t <sub>h</sub> Hold time, all synchronous inputs after CLK ↑		2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

3

HC MOS DEVICES

**TYPES SN54HC160, SN54HC161  
SN74HC160, SN74HC161  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC160 SN54HC161		SN74HC160 SN74HC161		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	6	14		4.2		5		MHz
			4.5 V	31	40		21		25		
			6 V	36	44		25		29		
$t_{pd}$	CLK	RCO	2 V		83	215		325		270	ns
			4.5 V		24	43		65		54	
			6 V		20	37		55		46	
$t_{pd}$	CLK	Any Q	2 V		80	205		310		255	ns
			4.5 V		25	41		62		51	
			6 V		21	35		53		43	
$t_{pd}$	ENT	RCO	2 V		62	195		295		245	ns
			4.5 V		17	39		59		49	
			6 V		14	33		50		42	
$t_{PHL}$	$\overline{CLR}$	Any Q	2 V		105	210		315		265	ns
			4.5 V		21	42		63		53	
			6 V		18	36		54		45	
$t_{PHL}$	$\overline{CLR}$	RCO	2 V		110	220		330		275	ns
			4.5 V		22	44		66		55	
			6 V		19	37		56		47	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	60 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**TYPES SN54HC162, SN54HC163  
SN74HC162, SN74HC163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC162 SN54HC163		SN74HC162 SN74HC163		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration, CLK high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub>	A, B, C, or D	2 V	150		225		190		ns
		4.5 V	30		45		38		
		6 V	26		38		32		
	$\overline{\text{LOAD}}$ low	2 V	135		205		170		
		4.5 V	27		41		34		
		6 V	23		35		29		
	ENP, ENT	2 V	170		225		215		
		4.5 V	34		51		43		
		6 V	29		43		37		
	$\overline{\text{CLR}}$ low	2 V	160		240		200		
		4.5 V	32		48		40		
		6 V	27		41		34		
	$\overline{\text{CLR}}$ inactive	2 V	160		240		200		
		4.5 V	32		48		40		
		6 V	27		41		34		
t <sub>h</sub>	Hold time, all synchronous inputs after CLK ↑	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

3

HCMOS DEVICES



**TYPES SN54HC162, SN54HC163  
SN74HC162, SN74HC163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC162 SN54HC163		SN74HC162 SN74HC163		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	6	14		4.2		5		MHz
			4.5 V	31	40		21		25		
			6 V	36	44		25		29		
$t_{\text{pd}}$	CLK	RCO	2 V		83	215		325		270	ns
			4.5 V		24	43		65		54	
			6 V		20	37		55		46	
$t_{\text{pd}}$	CLK	Any Q	2 V		80	205		310		255	ns
			4.5 V		25	41		62		51	
			6 V		21	35		53		43	
$t_{\text{pd}}$	ENT	RCO	2 V		62	195		295		245	ns
			4.5 V		17	39		59		49	
			6 V		14	33		50		42	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

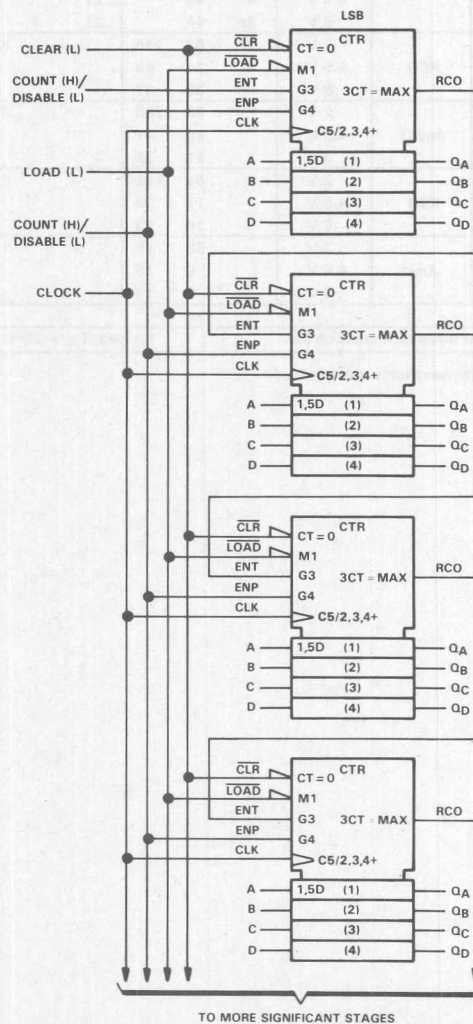
$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	60 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

## TYPICAL APPLICATION DATA

## N-BIT SYNCHRONOUS COUNTERS

This application demonstrates how the look-ahead carry circuit can be used to implement a high-speed n-bit counter. The 'HC160 and 'HC162 will count in BCD, and the 'HC161 and 'HC163 will count in binary. Virtually any count mode (modulo-N,  $N_1$ -to- $N_2$ ,  $N_1$ -to-maximum) can be used with this fast look-ahead circuit.



- AND-Gated (Enable/Disable) Serial Inputs
- Fully Buffered Clock and Serial Inputs
- Direct Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit shift registers feature AND-gated serial inputs and an asynchronous clear. The gated serial inputs (A and B) permit complete control over incoming data as a low at either input inhibits entry of the new data and resets the first flip-flop to the low level at the next clock pulse. A high-level input enables the other input, which will then determine the state of the first flip-flop. Data at the serial inputs may be changed while the clock is high or low, provided the minimum setup time requirements are met. Clocking occurs on the low-to-high-level transition of the clock input.

The SN54HC164 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC164 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

INPUTS				OUTPUTS		
CLR	CLK	A	B	Q <sub>A</sub>	Q <sub>B</sub> ... Q <sub>H</sub>	
L	X	X	X	L	L	L
H	L	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>H0</sub>
H	↑	H	H	H	Q <sub>An</sub>	Q <sub>Gn</sub>
H	↑	L	X	L	Q <sub>An</sub>	Q <sub>Gn</sub>
H	↑	X	L	L	Q <sub>An</sub>	Q <sub>Gn</sub>

H = high level (steady state), L = low level (steady state)

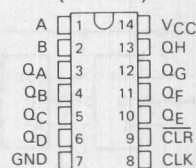
X = irrelevant (any input, including transitions)

↑ = transition from low to high level.

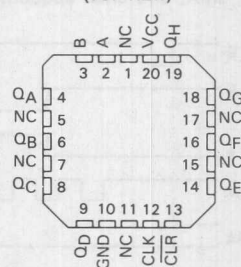
Q<sub>A0</sub>, Q<sub>B0</sub>, Q<sub>H0</sub> = the level of Q<sub>A</sub>, Q<sub>B</sub>, or Q<sub>H</sub>, respectively, before the indicated steady-state input conditions were established.

Q<sub>An</sub>, Q<sub>Gn</sub> = the level of Q<sub>A</sub> or Q<sub>G</sub> before the most-recent ↑ transition of the clock; indicates a one-bit shift.

SN54HC164 ... J PACKAGE  
SN74HC164 ... J OR N ORD (= SO) PACKAGE  
(TOP VIEW)

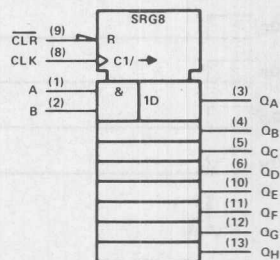


SN54HC164 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

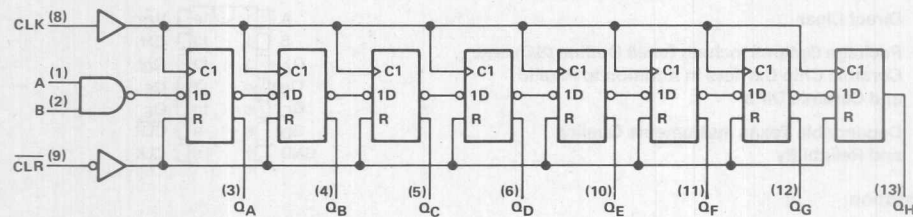
### logic symbol



Pin numbers shown are for J and N packages.

**TYPES SN54HC164, SN74HC164**  
**8-BIT PARALLEL-OUT SERIAL SHIFT REGISTERS**

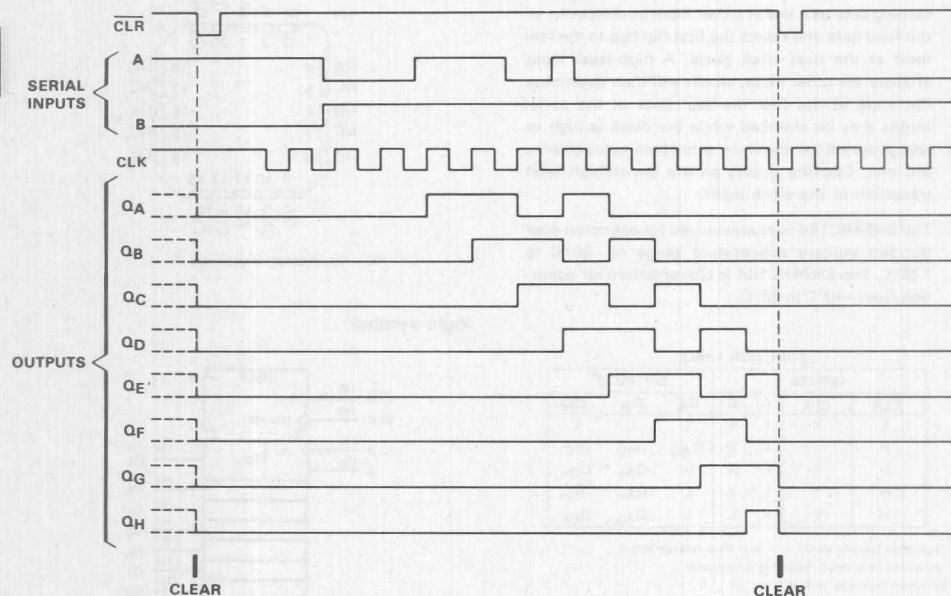
logic diagram (positive logic)



typical clear, shift, and clear sequences

3

HCMOS DEVICES



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

# **TYPES SN54HC164, SN74HC164** **8-BIT PARALLEL-OUT SERIAL SHIFT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC164		SN74HC164		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	28	
t <sub>w</sub>	Pulse duration	$\overline{\text{CLR}}$ low	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	17	25		21		
	CLK high or low		2 V	80	120		100		
			4.5 V	16	24		20		
			6 V	14	20		18		
t <sub>su</sub>	Setup time before CLK↑	Data	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	27	25		21		
	$\overline{\text{CLR}}$ inactive		2 V	100	150		125		
			4.5 V	20	30		25		
			6 V	27	25		21		
t <sub>h</sub>	Hold time, data after CLK↑		2 V	5	5		5		ns
			4.5 V	5	5		5		
			6 V	5	5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC164		SN74HC164		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	10		4.2		5		MHz
			4.5 V	31	54		21		25		
			6 V	36	62		25		28		
t <sub>PHL</sub>	$\overline{\text{CLR}}$	Any Q	2 V		140	205		295		255	ns
			4.5 V		28	41		59		51	
			6 V		24	35		51		46	
t <sub>pd</sub>	CLK	Any Q	2 V		115	175		265		220	ns
			4.5 V		23	35		53		44	
			6 V		20	30		45		38	
t <sub>t</sub>			2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	135 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMS DEVICES





## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC165, SN74HC165 PARALLEL-LOAD 8-BIT SHIFT REGISTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Complementary Outputs
- Direct Overriding Load (Data) Inputs
- Gated Clock Inputs
- Parallel-to-Serial Data Conversion
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC165 is an 8-bit serial shift register that, when clocked, shifts the data toward serial output  $Q_H$ . Parallel-in access to each stage is provided by eight individual direct data inputs that are enabled by a low level at the  $SH/\overline{LD}$  input. The 'HC165 also features a clock inhibit function and a complementary serial output  $\overline{Q}_H$ .

Clocking is accomplished by a low-to-high transition of the CLK input while  $SH/\overline{LD}$  is held high and CLK INH is held low. The functions of the CLK and CLK INH (clock inhibit) inputs are interchangeable. Since a low CLK input and a low-to-high transition of CLK INH will also accomplish clocking, CLK INH should be changed to the high level only while the CLK input is high. Parallel loading is inhibited when  $SH/\overline{LD}$  is held high. The parallel inputs to the register are enabled while  $SH/\overline{LD}$  is low independently of the levels of CLK, CLK INH, or SER inputs.

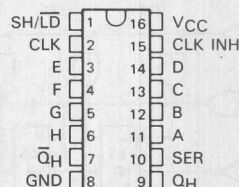
The SN54HC165 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC165 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

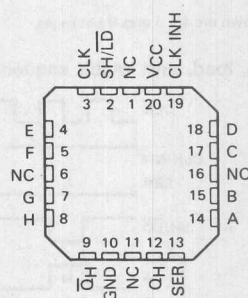
INPUTS			FUNCTION
$SH/\overline{LD}$	CLK	CLK INH	
L	X	X	Parallel load
H	H	X	No change
H	X	H	No change
H	L	$\uparrow$	Shift
H	$\uparrow$	L	Shift

Shift — content of each internal register shifts toward serial output  $Q_H$ . Data at serial input is shifted into first register.

SN54HC165...J PACKAGE  
SN74HC165...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

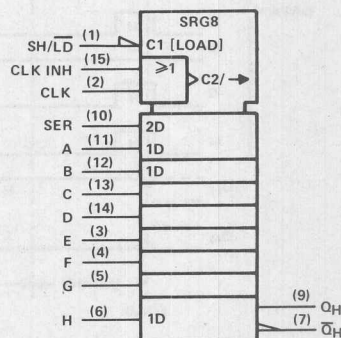


SN54HC165...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol

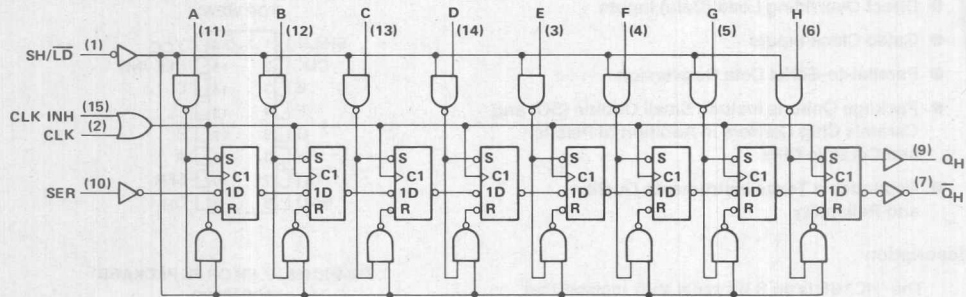


Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

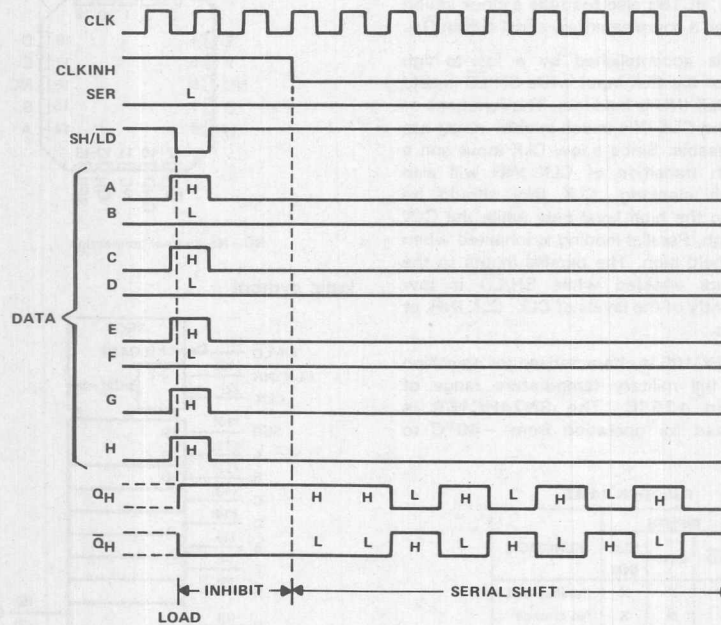
logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

typical shift, load, and inhibit sequences



HCMOS DEVICES

**TYPES SN54HC165, SN74HC165**  
**PARALLEL-LOAD 8-BIT SHIFT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC165		SN74HC165		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	SH/ $\overline{\text{LD}}$ low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
	CLK high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub>	SH/ $\overline{\text{LD}}$ high before CLK↑	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
	SER before CLK↑	2 V	40		60		50		ns
		4.5 V	8		12		10		
		6 V	7		10		9		
	CLK INH low before CLK↑	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLK INH high before CLK↓	2 V	40		60		50		ns
		4.5 V	8		12		10		
		6 V	7		10		9		
t <sub>h</sub>	Data before SH/ $\overline{\text{LD}}$ ↑	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
	SER data after CLK↑	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		
	PAR data after SH/ $\overline{\text{LD}}$ ↑	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		

3

HCMOS DEVICES

TYPES SN54HC165, SN74HC165  
PARALLEL-LOAD 8-BIT SHIFT REGISTERS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC165		SN74HC165		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	13		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	62		25		29		
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub> or $\overline{\text{Q}}_{\text{H}}$	2 V		80	150		225		190	ns
			4.5 V		20	30		45		38	
			6 V		16	26		38		32	
t <sub>pd</sub>	CLK	Q <sub>H</sub> or $\overline{\text{Q}}_{\text{H}}$	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>pd</sub>	H	Q <sub>H</sub> or $\overline{\text{Q}}_{\text{H}}$	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	3		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	75 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC166, SN74HC166 PARALLEL-LOAD 8-BIT SHIFT REGISTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Synchronous Load
- Direct Overriding Clear
- Parallel to Serial Conversion
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

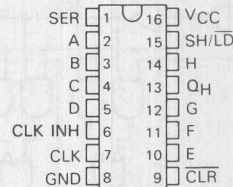
The 'HC166 parallel-in or serial-in, serial-out registers feature gated clock inputs and an overriding clear input. The parallel-in or serial-in modes are established by the shift/load input. When high, this input enables the serial data input and couples the eight flip-flops for serial shifting with each clock pulse. When low, the parallel (broadside) data inputs are enabled and synchronous loading occurs on the next clock pulse. During parallel loading, serial data flow is inhibited. Clocking is accomplished on the low-to-high-level edge of the clock pulse through a two-input positive NOR gate permitting one input to be used as a clock-enable or clock-inhibit function. Holding either of the clock inputs high inhibits clocking; holding either low enables the other clock input. This, of course, allows the system clock to be free-running and the register can be stopped on command with the other clock input. The clock-inhibit input should be changed to the high level only when the clock input is high. A direct clear input overrides all other inputs, including the clock, and resets all flip-flops to zero.

The SN54HC166 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC166 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

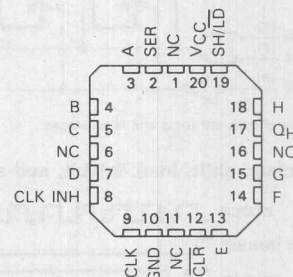
FUNCTION TABLE

CLEAR	INPUTS					INTERNAL OUTPUTS		OUTPUT $Q_H$
	SHIFT/LOAD	CLOCK INHIBIT	CLOCK	SERIAL	PARALLEL $A \dots H$	$Q_A$	$Q_B$	
L	X	X	X	X	X	L	L	L
H	X	L	L	X	X	$Q_{A0}$	$Q_{B0}$	$Q_{H0}$
H	L	L	$\uparrow$	X	$a \dots h$	a	b	h
H	H	L	$\uparrow$	H	X	H	$Q_{An}$	$Q_{Gn}$
H	H	L	$\uparrow$	L	X	L	$Q_{An}$	$Q_{Gn}$
H	X	H	$\uparrow$	X	X	$Q_{A0}$	$Q_{B0}$	$Q_{H0}$

SN54HC166 ... J PACKAGE  
SN74HC166 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

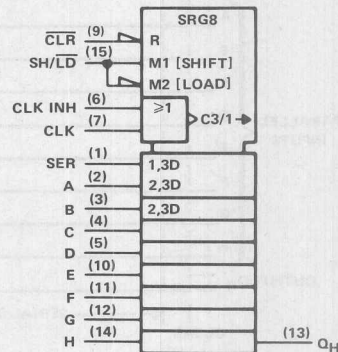


SN54HC166 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol

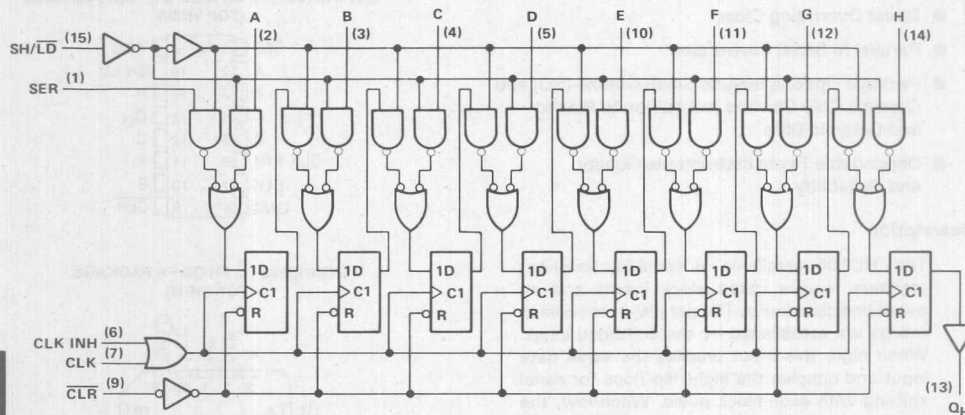


Pin numbers shown are for J and N packages.



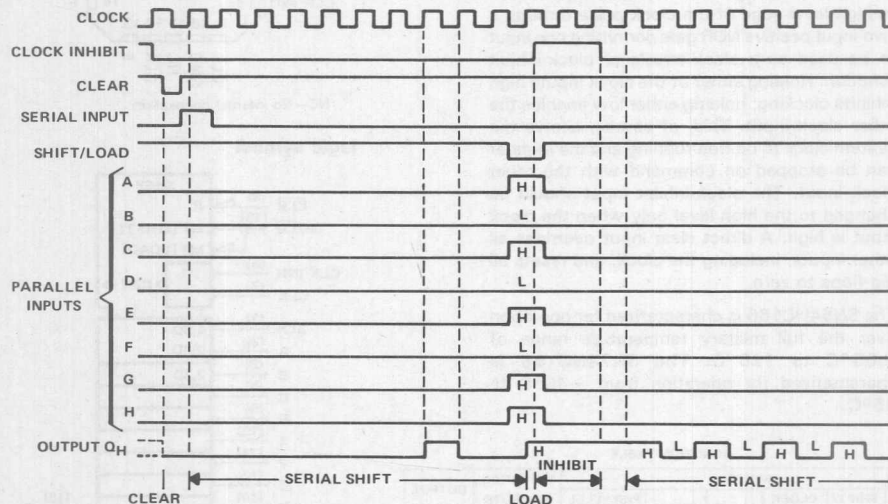
# TYPES SN54HC166, SN74HC166 PARALLEL-LOAD 8-BIT SHIFT REGISTERS

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

typical clear, shift, load, inhibit, and shift sequences



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

3

HC MOS DEVICES



**TYPES SN54HC166, SN74HC166**  
**PARALLEL-LOAD 8-BIT SHIFT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC166		SN74HC166		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	$\overline{\text{CLR}}$ low	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	17	26		21		
	CLK high or low	2 V	80	120		100			
		4.5 V	16	24		20			
		6 V	14	20		17			
t <sub>su</sub>	Setup time	SH/ $\overline{\text{LD}}$ high before CLK $\uparrow$	2 V	145	220		180		ns
			4.5 V	29	44		36		
			6 V	25	38		31		
		SER before CLK $\uparrow$	2 V	80	120		100		
			4.5 V	16	24		20		
			6 V	14	20		17		
	Data before SH/ $\overline{\text{LD}}$ $\uparrow$	CLK INH before CLK $\uparrow$	2 V	100	150		125		
			4.5 V	20	30		25		
			6 V	17	26		21		
		Data before SH/ $\overline{\text{LD}}$ $\uparrow$	2 V	80	120		100		
			4.5 V	16	24		20		
			6 V	14	20		17		
t <sub>h</sub>	Hold time	$\overline{\text{CLR}}$ inactive before CLK $\uparrow$	2 V	40	60		50		ns
			4.5 V	8	12		10		
			6 V	7	10		9		
		SH/ $\overline{\text{LD}}$ high after CLK $\uparrow$	2 V	0	0		0		
			4.5 V	0	0		0		
			6 V	0	0		0		
		SER after CLK $\uparrow$	2 V	5	5		5		
			4.5 V	5	5		5		
			6 V	5	5		5		
		CLK INH after CLK $\uparrow$	2 V	0	0		0		
			4.5 V	0	0		0		
			6 V	0	0		0		
		Data after CLK $\uparrow$	2 V	5	5		5		
			4.5 V	5	5		5		
			6 V	5	5		5		
		$\overline{\text{CLR}}$ active after CLK $\uparrow$	2 V	0	0		0		
			4.5 V	0	0		0		
			6 V	0	0		0		

3

HCMOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM	TO	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC166		SN74HC166		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	6	11		4.2		5		MHz
			4.5 V	31	36		21		25		
			6 V	36	45		25		29		
$t_{\text{PHL}}$	$\overline{\text{CLR}}$	$Q_H$	2 V		62	120		180		150	ns
			4.5 V		18	24		36		30	
			6 V		13	20		31		26	
$t_{\text{pd}}$	CLK	$Q_H$	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

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$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

HCMOS DEVICES

D2684, DECEMBER 1982—REVISED MARCH 1984

- High-Current 3-State Outputs Interface Directly with System Bus or Can Drive up to 15 LSTTL Loads
- Gated Output-Control Lines for Enabling or Disabling the Outputs
- Fully Independent Clock Virtually Eliminates Restrictions for Operating in One of Two Modes
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

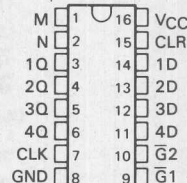
### description

The 'HC173 four-bit registers include D-type flip-flops featuring totem-pole three-state outputs capable of driving highly capacitive or relatively low-impedance loads. The high-impedance third state and increased drive provide these flip-flops with the capability of being connected directly to and driving the lines in a bus-organized system without need for interface or pull-up components.

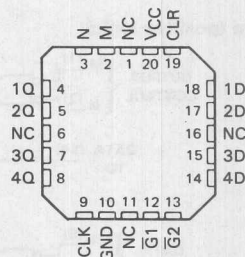
Gated enable inputs are provided on these devices for controlling the entry of data into the flip-flops. When both data-enable inputs are low, data at the D inputs are loaded into their respective flip-flops on the next positive transition of the clock input. Gate output control inputs are also provided. When both are low, the normal logic states (high or low levels) of the four outputs are available for driving the loads or bus lines. The outputs are disabled independently from the level of the clock by a high logic level at either output control input. The outputs then present a high impedance and neither load nor drive the bus line. Detailed operation is given in the function table.

The SN54HC173 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC173 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC173... J PACKAGE  
SN74HC173... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC173... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE

CLEAR	CLOCK	INPUTS		DATA D	OUTPUT Q
		DATA ENABLE G1	DATA ENABLE G2		
H	X	X	X	X	L
L	L	X	X	X	Q <sub>0</sub>
L	↑	H	X	X	Q <sub>0</sub>
L	↑	X	H	X	Q <sub>0</sub>
L	↑	L	L	L	L
L	↑	L	L	H	H

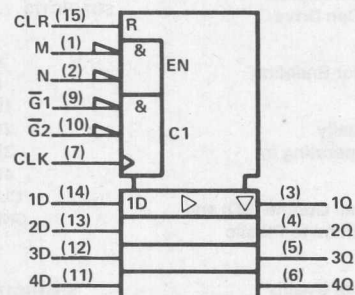
When either M or N (or both) is (are) high the output is disabled to the high-impedance state; however sequential operation of the flip-flops is not affected.

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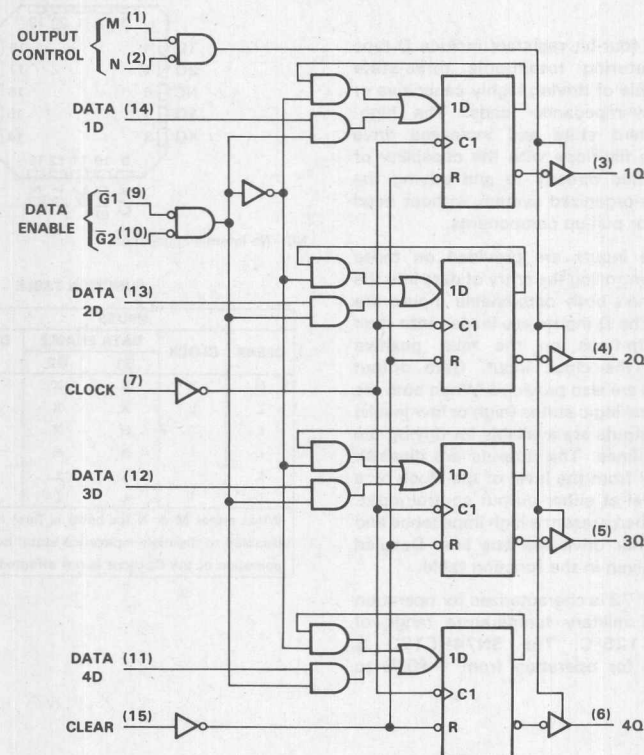
HC MOS DEVICES

# **TYPES SN54HC173, SN74HC173** **4-BIT D-TYPE REGISTERS WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

# TYPES SN54HC173, SN74HC173 4-BIT D-TYPE REGISTERS WITH 3-STATE OUTPUTS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC173		SN74HC173		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Input clock frequency		2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub> Pulse duration	CLK high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
	CLR high	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		17		
t <sub>su</sub> Setup time before CLK ↑	$\overline{G}1$ and $\overline{G}2$	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	Data	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		25		21		
	CLR inactive	2 V	90		135		115		ns
		4.5 V	18		27		23		
		6 V	15		23		19		
t <sub>h</sub> Hold time after CLK ↑	$\overline{G}1$ and $\overline{G}2$	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		
	Data	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

3

HCMOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC173		SN74HC173		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	8		4.2		5		MHz
			4.5 V	31	46		21		25		
			6 V	36	55		25		29		
t <sub>PHL</sub>	CLR	Any	2 V		78	150		225		190	ns
			4.5 V		21	30		45		38	
			6 V		20	26		38		32	
t <sub>pd</sub>	CLK	Any	2 V		78	150		225		190	ns
			4.5 V		21	30		45		38	
			6 V		20	26		38		32	
t <sub>en</sub>	M or N	Any	2 V		78	150		225		190	ns
			4.5 V		20	30		45		38	
			6 V		15	26		38		32	
t <sub>dis</sub>	M or N	Any	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		16	26		38		32	
t <sub>t</sub>		Any	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	
C <sub>pd</sub>		Power dissipation capacitance				No load, T <sub>A</sub> = 25 °C		29 pF typ			

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC173		SN74HC173		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{\text{PHL}}$	CLR	Any	2 V		100	200		300		250	ns
			4.5 V		28	40		60		50	
			6 V		21	34		51		43	
$t_{\text{pd}}$	CLK	Any	2 V		100	200		300		250	ns
			4.5 V		28	40		60		50	
			6 V		21	34		51		43	
$t_{\text{en}}$	M or N	Any	2 V		100	200		300		250	ns
			4.5 V		28	40		60		50	
			6 V		21	34		51		43	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC174, SN54HC175 SN74HC174, SN74HC175 HEX/QUADRUPL D-TYPE FLIP-FLOPS WITH CLEAR

D2684, DECEMBER 1982—REVISED MARCH 1984

- 'HC174 Contains Six Flip-Flops with Single-Rail Outputs
- 'HC175 Contains Four Flip-Flops with Double-Rail Outputs
- Applications Include:
  - Buffer/Storage Registers
  - Shift Registers
  - Pattern Generators
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These monolithic, positive-edge triggered D-type flip-flops have a direct clear input and the 'HC175 features complementary outputs from each flip-flop.

Information at the D inputs meeting the setup time requirements is transferred to the outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a particular voltage level and is not directly related to the transition time of the positive-going edge of the clock pulse. When the clock input is at either the high or low level, the D input signal has no effect at the output.

The SN54HC174 and SN54HC175 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC174 and SN74HC175 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

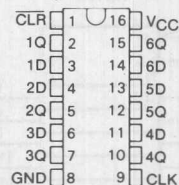
FUNCTION TABLE  
(EACH FLIP-FLOP)

INPUTS			OUTPUTS	
CLR	CLK	D	Q	$\bar{Q}^{\dagger}$
L	X	X	L	H
H	$\uparrow$	H	H	L
H	$\uparrow$	L	L	H
H	L	X	$Q_0$	$\bar{Q}_0$

$^{\dagger}$  'HC175 only

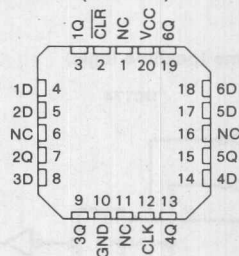
### SN54HC174... J PACKAGE

#### SN74HC174... J OR N OR D (= SO) PACKAGE (TOP VIEW)



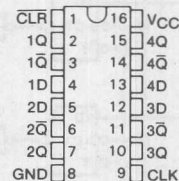
### SN54HC174... FH OR FK PACKAGE

#### (TOP VIEW)



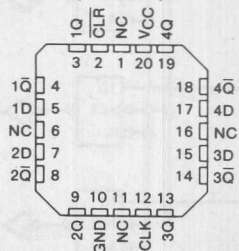
### SN54HC175... J PACKAGE

#### SN74HC175... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC175... FH OR FK PACKAGE

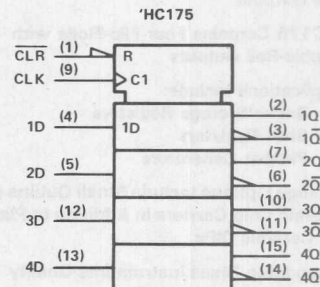
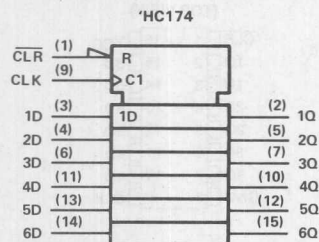
#### (TOP VIEW)



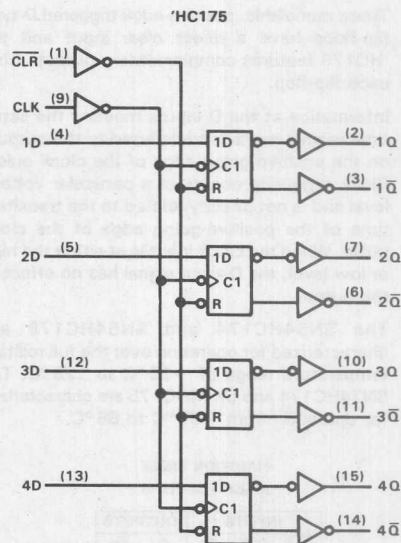
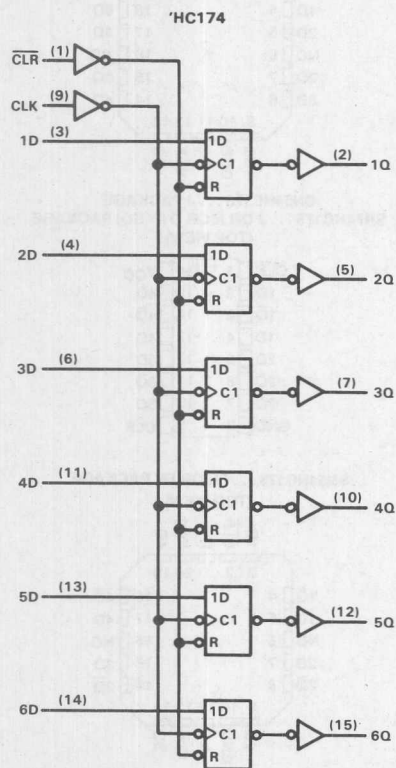
NC—No internal connection

**TYPES SN54HC174, SN54HC175  
SN74HC174, SN74HC175  
HEX/QUADRUPLE D-TYPE FLIP-FLOPS WITH CLEAR**

logic symbols



logic diagrams (positive logic)



Pin numbers shown are for J and N packages.

3

HC MOS DEVICES

See Table IV, page 2-10.

'HC174 timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC174		SN74HC174		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock Frequency		2 V	0	6	0	4.2	0	5	MHz
			4.5 V	0	31	0	21	0	25	
			6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	CLR low	2 V	80	120	100	ns			
			4.5 V	16	24	20				
			6 V	14	20	17				
		CLK high or low	2 V	80	120	100				
			4.5 V	16	24	20				
			6 V	14	20	17				
t <sub>su</sub>	Setup time before CLK↑	Data	2 V	100	150	125	ns			
			4.5 V	20	30	25				
			6 V	17	25	21				
		CLR inactive	2 V	100	150	125				
			4.5 V	20	30	25				
			6 V	17	25	21				
t <sub>h</sub>	Hold time, data after CLK↑	2 V	0	0	0	ns				
		4.5 V	0	0	0					
		6 V	0	0	0					

'HC174 switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC174		SN74HC174		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	9		4.2		5		MHz
			4.5 V	31	44		21		25		
			6 V	36	50		25		29		
t <sub>pd</sub>	CLR	Any	2 V		58	160		240		200	ns
			4.5 V		17	32		48		40	
			6 V		14	27		41		34	
	CLK	Any	2 V		58	160		240		200	
			4.5 V		17	32		48		40	
			6 V		14	27		41		34	
t <sub>t</sub>		Any	2 V		38	75		110		90	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	27 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMS DEVICES

# **TYPES SN54HC175, SN74HC175** **HEX/QUADRUPLE D-TYPE FLIP-FLOPS WITH CLEAR**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

**'HC175 timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC175		SN74HC175		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>		2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	$\overline{\text{CLR}}$ low	2 V	80	120	100	ns		
			4.5 V	16	24	20			
			6 V	14	20	17			
	CLK high or low	2 V	80	120	100				
		4.5 V	16	24	20				
		6 V	14	20	17				
t <sub>su</sub>	Setup time before CLK↑	Data	2 V	100	150	125	ns		
			4.5 V	20	30	25			
			6 V	17	25	21			
	$\overline{\text{CLR}}$ inactive	2 V	100	150	125				
		4.5 V	20	30	25				
		6 V	17	25	21				
t <sub>h</sub>	Hold time, data after CLK↑	2 V	0	0	0	ns			
		4.5 V	0	0	0				
		6 V	0	0	0				

**'HC175 switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC175		SN74HC175		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	12		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		29		
t <sub>pd</sub>	CLR	Any	2 V		52	150		255		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
	CLK	Any	2 V		58	150		255		190	
			4.5 V		16	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		38	75		110		90	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	30 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC180, SN74HC180 9-BIT ODD/EVEN PARITY GENERATORS/CHECKERS

D2484, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These universal, monolithic, 9-bit (8 data bits plus 1 parity bit) parity generators/checkers, feature odd/even outputs and control inputs to facilitate operation in either odd- or even-parity applications. Depending on whether even or odd parity is being generated or checked, the even or odd inputs can be utilized as the parity or 9th-bit input. The word-length capability is easily expanded by cascading.

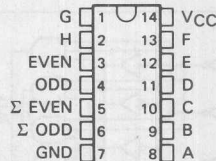
The SN54HC180 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ; and the SN74HC180 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

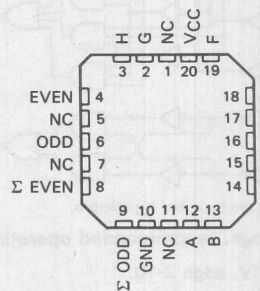
INPUTS			OUTPUTS	
$\Sigma$ OF H's AT A THRU H	EVEN	ODD	$\Sigma$ EVEN	$\Sigma$ ODD
EVEN	H	L	H	L
ODD	H	L	L	H
EVEN	L	H	L	H
ODD	L	H	H	L
X	H	H	L	L
X	L	L	H	H

H = high level, L = low level, X = irrelevant

SN54HC180... J PACKAGE  
SN74HC180... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

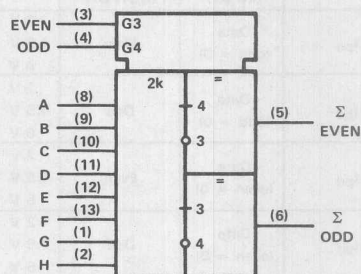


SN54HC180... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

## logic symbol



Pin numbers shown are for J and N packages.

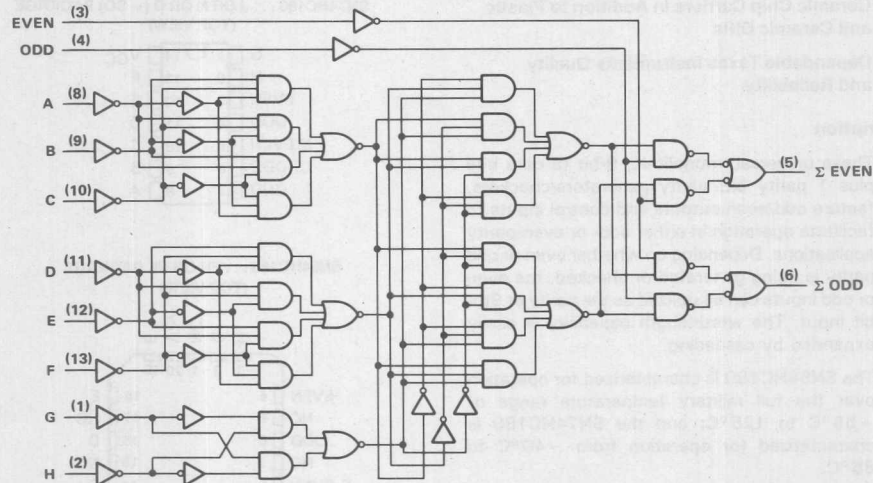
3

HC MOS DEVICES



# **TYPES SN54HC180, SN74HC180** **9-BIT ODD/EVEN PARITY GENERATORS/CHECKERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

## **maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HC180		SN74HC180		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Data (odd = 0)	Even	2 V		119	260		390		325	ns
			4.5 V		36	52		78		65	
			6 V		32	44		66		55	
$t_{pd}$	Data (odd = 0)	Odd	2 V		113	245		370		305	ns
			4.5 V		33	49		74		61	
			6 V		24	42		63		52	
$t_{pd}$	Data (even = 0)	Even	2 V		119	260		390		325	ns
			4.5 V		36	52		78		65	
			6 V		32	44		66		55	
$t_{pd}$	Data (even = 0)	Odd	2 V		113	245		370		305	ns
			4.5 V		33	49		74		61	
			6 V		24	42		63		52	
$t_{pd}$	Even or Odd	Even or Odd	2 V		49	110		165		140	ns
			4.5 V		15	22		33		28	
			6 V		12	19		28		24	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ C$	60 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



- Single Down/Up Count Control Line
- Look-Ahead Circuitry Enhances Speed of Cascaded Counters
- Fully Synchronous in Count Modes
- Asynchronously Presetable with Load Control
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC190 and 'HC191 are synchronous, reversible up/down counters. The 'HC190 is a 4-bit decade counter and the 'HC191 is a 4-bit binary counter. Synchronous counting operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the steering logic. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple clock) counters.

The outputs of the four flip-flops are triggered on a low-to-high-level transition of the clock input if the enable input ( $\overline{\text{CTEN}}$ ) is low. A high at  $\overline{\text{CTEN}}$  inhibits counting. The direction of the count is determined by the level of the down/up ( $\text{D}/\overline{\text{U}}$ ) input. When  $\text{D}/\overline{\text{U}}$  is low, the counter counts up and when  $\text{D}/\overline{\text{U}}$  is high, it counts down.

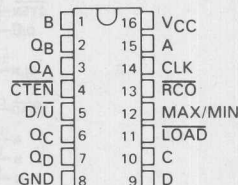
These counters feature a fully independent clock circuit. Changes at the control inputs ( $\overline{\text{CTEN}}$  and  $\text{D}/\overline{\text{U}}$ ) that will modify the operating mode have no effect on the contents of the counter until clocking occurs. The function of the counter will be dictated solely by the condition meeting the stable setup and hold times.

These counters are fully programmable; that is, the outputs may each be preset to either level by placing a low on the load input and entering the desired data at the data inputs. The output will change to agree with the data inputs independently of the level of the clock input. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

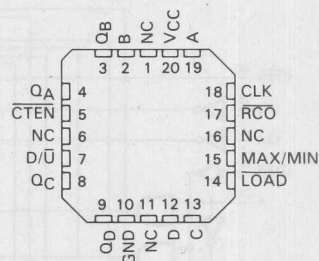
Two outputs have been made available to perform the cascading function: ripple clock and maximum/minimum count. The latter output produces a high-level output pulse with a duration approximately equal to one complete cycle of the clock while the count is zero (all outputs low) counting down or maximum (9 or 15) counting up. The ripple clock output produces a low-level output pulse under those same conditions but only while the clock input is low. The counters can be easily cascaded by feeding the ripple clock output to the enable input of the succeeding counter if parallel clocking is used, or to the clock input if parallel enabling is used. The maximum/minimum count output can be used to accomplish look-ahead for high-speed operation.

The SN54HC190 and SN54HC191 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC190 and SN74HC191 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC190, SN54HC191 ... J PACKAGE  
SN74HC190, SN74HC191 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC190, SN54HC191 ... FH OR FK PACKAGE  
(TOP VIEW)



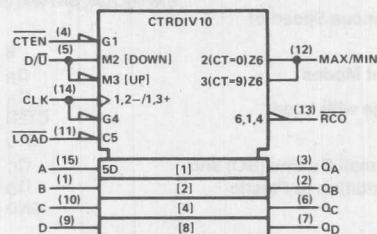
NC — No internal connection

3

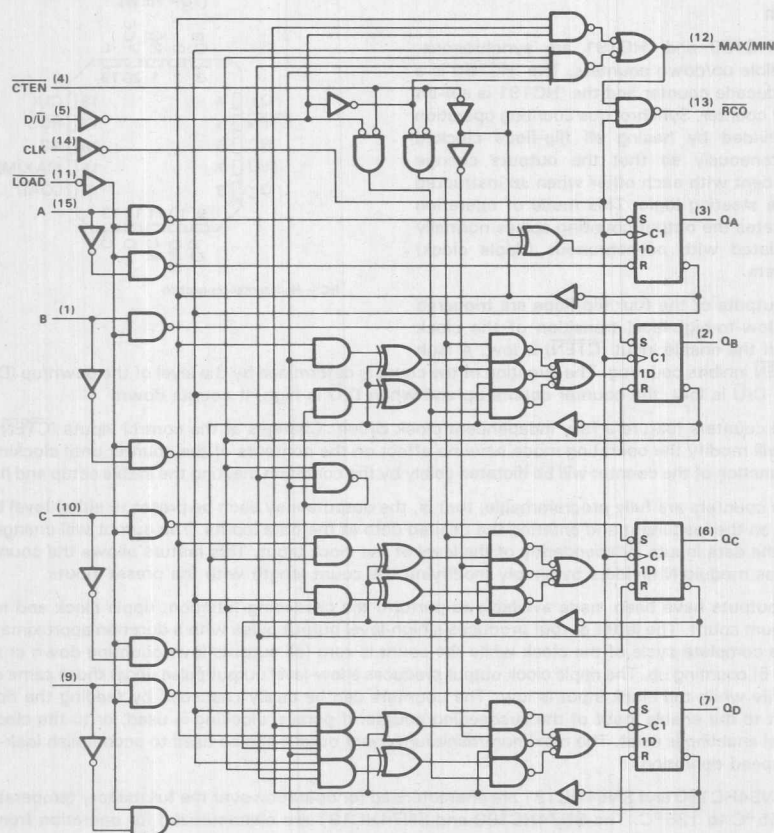
HC MOS DEVICES

# **TYPES SN54HC190, SN74HC190** **SYNCHRONOUS 4-BIT UP/DOWN DECADE COUNTERS**

'HC190 logic symbol



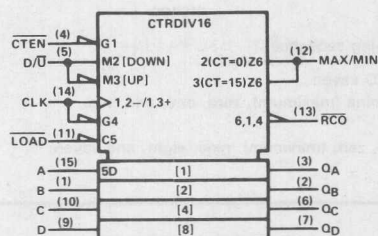
'HC190 logic diagram (positive logic)



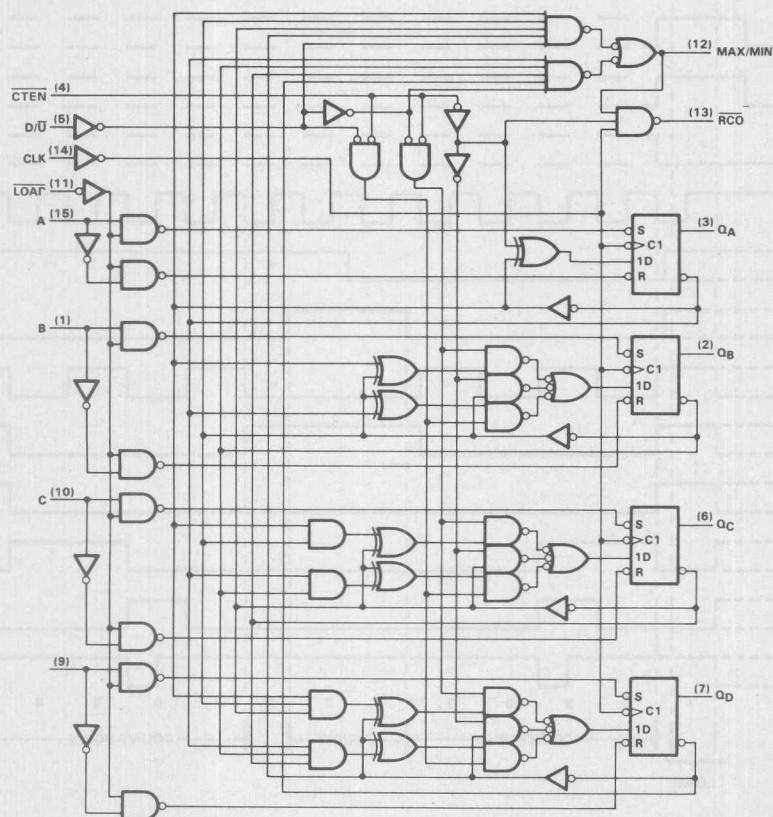
Pin numbers shown are for J and N packages.

# TYPES SN54HC191, SN74HC191 SYNCHRONOUS 4-BIT UP/DOWN BINARY COUNTERS

HC191 logic symbol



HC191 logic diagram (positive logic)



Pin numbers shown are for J and N packages.

# **TYPES SN54HC190, SN74HC190** **SYNCHRONOUS 4-BIT UP/DOWN DECADE COUNTERS**

typical load, count, and inhibit sequences

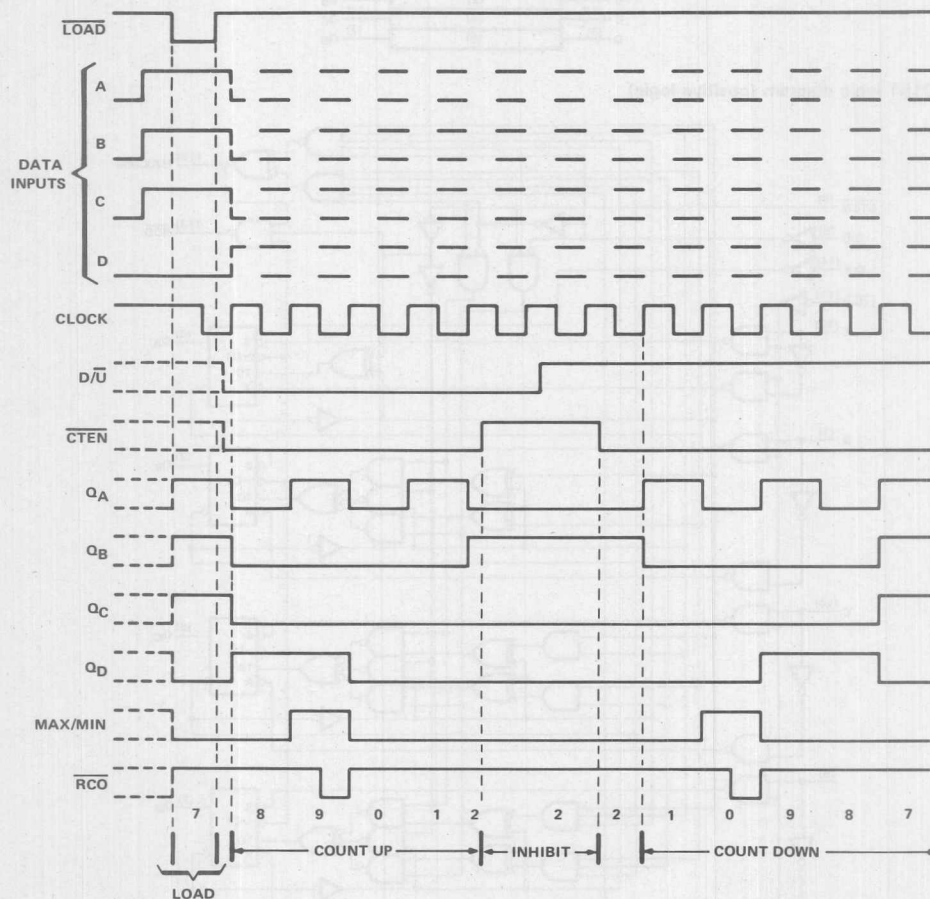
'HC190

Illustrated below is the following sequence:

1. Load (preset) to BCD seven.
2. Count up to eight, nine (maximum), zero, one, and two.
3. Inhibit.
4. Count down to one, zero (minimum), nine, eight, and seven.

3

HCMOS DEVICES



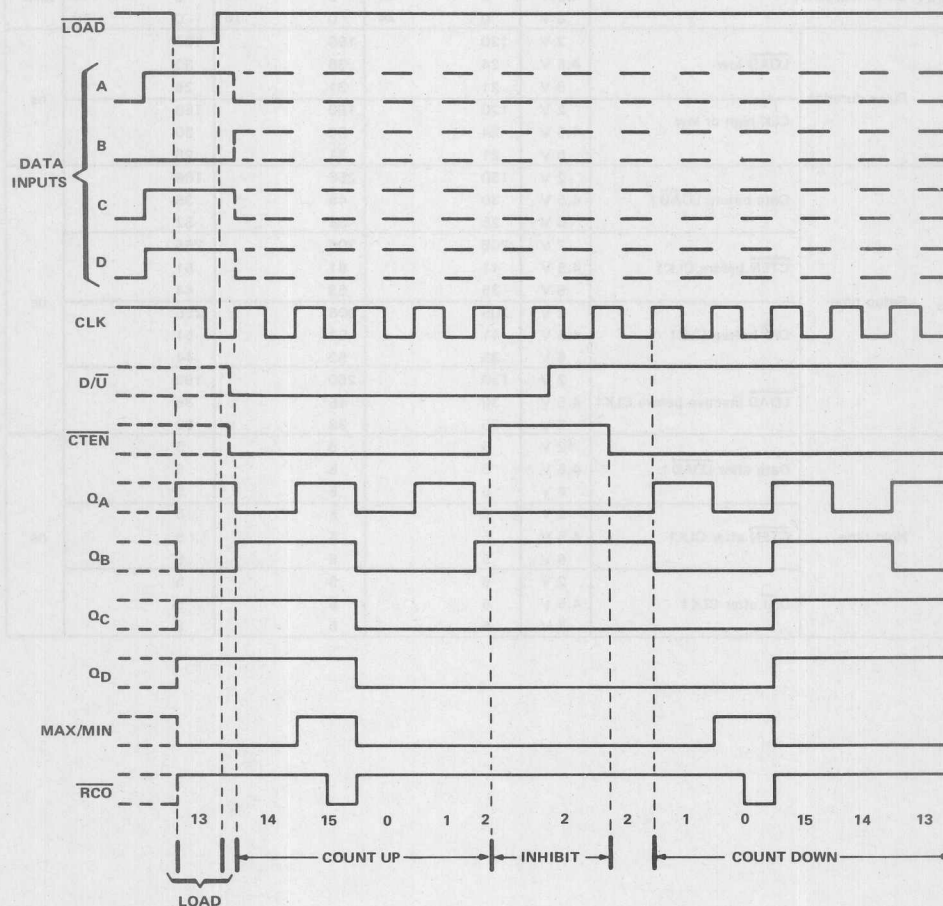
**TYPES SN54HC191, SN74HC191**  
**SYNCHRONOUS 4-BIT UP/DOWN BINARY COUNTERS**

typical load, count, and inhibit sequences

HC191

Illustrated below is the following sequence:

1. Load (preset) to binary thirteen.
2. Count up to fourteen, fifteen (maximum), zero, one, and two.
3. Inhibit.
4. Count down to one, zero (minimum), fifteen, fourteen, and thirteen.



3

HCMOS DEVICES

# **TYPES SN54HC190, SN54HC191, SN74HC190, SN74HC191** **SYNCHRONOUS 4-BIT UP/DOWN DECADE AND BINARY COUNTERS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC190 SN54HC191		SN74HC190 SN74HC191		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency		2 V	0	4.2	0	2.8	0	3.3	MHz
		4.5 V	0	21	0	14	0	17	
		6 V	0	24	0	16	0	19	
t <sub>w</sub> Pulse duration	LOAD low	2 V	120		180		150		ns
		4.5 V	24		36		30		
		6 V	21		31		26		
	CLK high or low	2 V	120		180		150		
		4.5 V	24		36		30		
		6 V	21		31		26		
t <sub>su</sub> Setup time	Data before LOAD ↑	2 V	150		256		188		ns
		4.5 V	30		46		38		
		6 V	25		38		32		
	CTEN before CLK ↑	2 V	205		306		255		
		4.5 V	41		61		51		
		6 V	35		53		44		
	D/ $\bar{U}$ before CLK ↑	2 V	205		306		255		
		4.5 V	41		61		51		
		6 V	35		53		44		
	LOAD inactive before CLK ↑	2 V	150		250		190		
		4.5 V	30		45		38		
		6 V	25		38		32		
t <sub>h</sub> Hold time	Data after LOAD ↑	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		
	CTEN after CLK ↑	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		
	D/ $\bar{U}$ after CLK ↑	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		



# **TYPES SN54HC190, SN54HC191, SN74HC190, SN74HC191** **SYNCHRONOUS 4-BIT UP/DOWN DECADE AND BINARY COUNTERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC190 SN54HC191		SN74HC190 SN74HC191		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	4.2	8		2.8		3.3		MHz
			4.5 V	21	42		14		17		
			6 V	24	48		16		19		
$t_{\text{pd}}$	$\overline{\text{LOAD}}$	Any Q	2 V		130	264		396		330	ns
			4.5 V		40	53		79		66	
			6 V		33	45		67		56	
$t_{\text{pd}}$	A, B, C, or D	$Q_A, Q_B$ $Q_C$ , or $Q_D$	2 V		135	240		360		300	ns
			4.5 V		36	48		72		60	
			6 V		30	41		61		51	
$t_{\text{pd}}$	CLK	$\overline{\text{RCO}}$	2 V		58	120		180		150	ns
			4.5 V		17	24		36		30	
			6 V		14	21		31		26	
$t_{\text{pd}}$	CLK	Any Q	2 V		107	192		288		240	ns
			4.5 V		31	38		58		48	
			6 V		26	32		49		41	
$t_{\text{pd}}$	CLK	MAX/MIN	2 V		123	252		378		315	ns
			4.5 V		39	50		76		63	
			6 V		32	43		65		54	
$t_{\text{pd}}$	D/ $\overline{U}$	$\overline{\text{RCO}}$	2 V		102	228		342		285	ns
			4.5 V		29	46		68		57	
			6 V		24	38		59		49	
$t_{\text{pd}}$	D/U	MAX/MIN	2 V		86	192		288		240	ns
			4.5 V		24	38		58		48	
			6 V		20	32		49		41	
$t_{\text{pd}}$	$\overline{\text{CTEN}}$	$\overline{\text{RCO}}$	2 V		50	132		198		165	ns
			4.5 V		15	26		40		33	
			6 V		13	23		34		28	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

3

## HCMOS DEVICES

**TYPES SN54HC192, SN54HC193  
SN74HC192, SN74HC193  
SYNCHRONOUS 4-BIT UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)**

D2684, DECEMBER 1982—REVISED MARCH 1984

**Look-Ahead Circuitry Enhances Cascaded  
Counters**

- Fully Synchronous in Count Modes
- Parallel Asynchronous Load for Modulo-N Count Lengths
- Asynchronous Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

The 'HC192 and 'HC193 are synchronous, reversible up/down counters. The 'HC192 is a 4-bit decade counter and the 'HC193 is a 4-bit binary counter. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincidentally with each other when so instructed by the steering logic. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple clock) counters.

The outputs of the four flip-flops are triggered by a low-to-high-level transition of either count (clock) input (Up or Down). The direction of counting is determined by which count input is pulsed while the other count input is high.

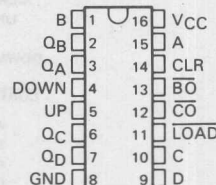
All four counters are fully programmable; that is, each output may be preset to either level by placing a low on the load input and entering the desired data at the data inputs. The output will change to agree with the data inputs independently of the count pulses. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

A clear input has been provided that forces all outputs to the low level when a high level is applied. The clear function is independent of the count and the load inputs.

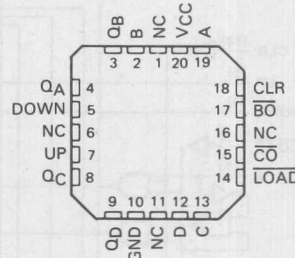
These counters were designed to be cascaded without the need for external circuitry. The borrow output ( $\overline{BO}$ ) produces a low-level pulse while the count is zero (all outputs low) and the count-down is low. Similarly, the carry output ( $\overline{CO}$ ) produces a low-level pulse while the count is maximum (9 or 15) and the count-up input is low. The counters can then be easily cascaded by feeding the borrow and carry outputs to the count-down and count-up inputs, respectively, of the succeeding counter.

The SN54HC192 and SN54HC193 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC192 and SN74HC193 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC192, SN54HC193... J PACKAGE  
SN74HC192, SN74HC193... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC192, SN54HC193... FH OR FK PACKAGE  
(TOP VIEW)



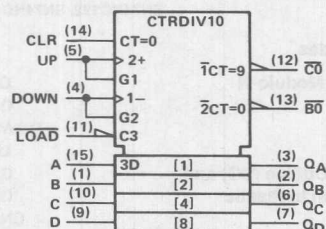
NC—No internal connection

3

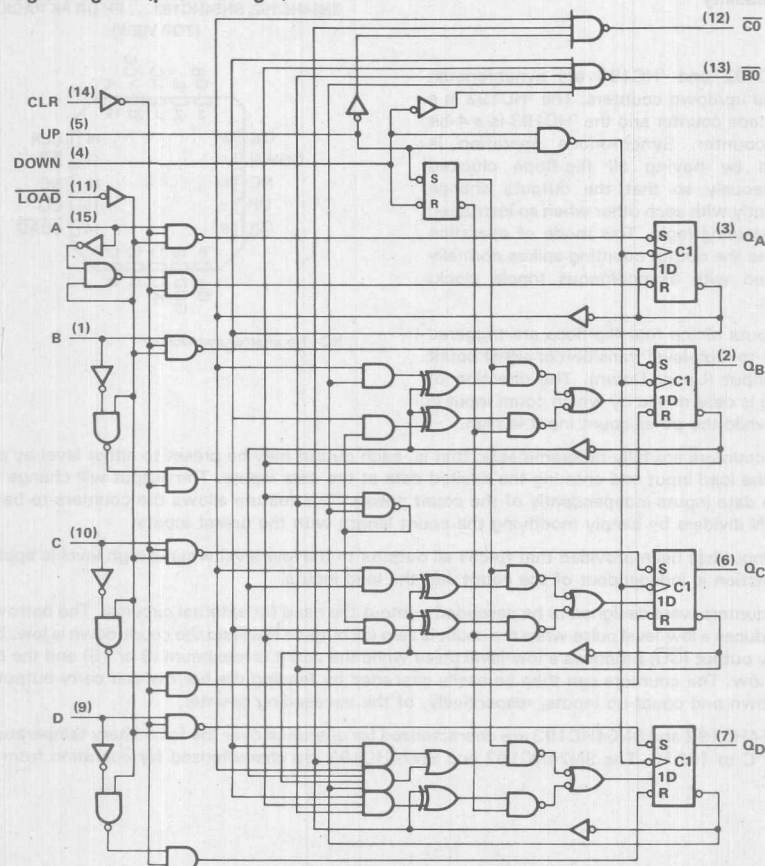
3  
HCMOS DEVICES

# **TYPES SN54HC192, SN74HC192** **SYNCHRONOUS 4-BIT UP/DOWN DECADE COUNTERS (DUAL CLOCK WITH CLEAR)**

'HC192 logic symbol



'HC192 logic diagram (positive logic)



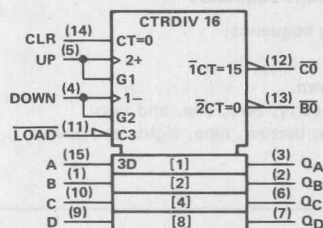
Pin numbers shown are for J and N packages.

3

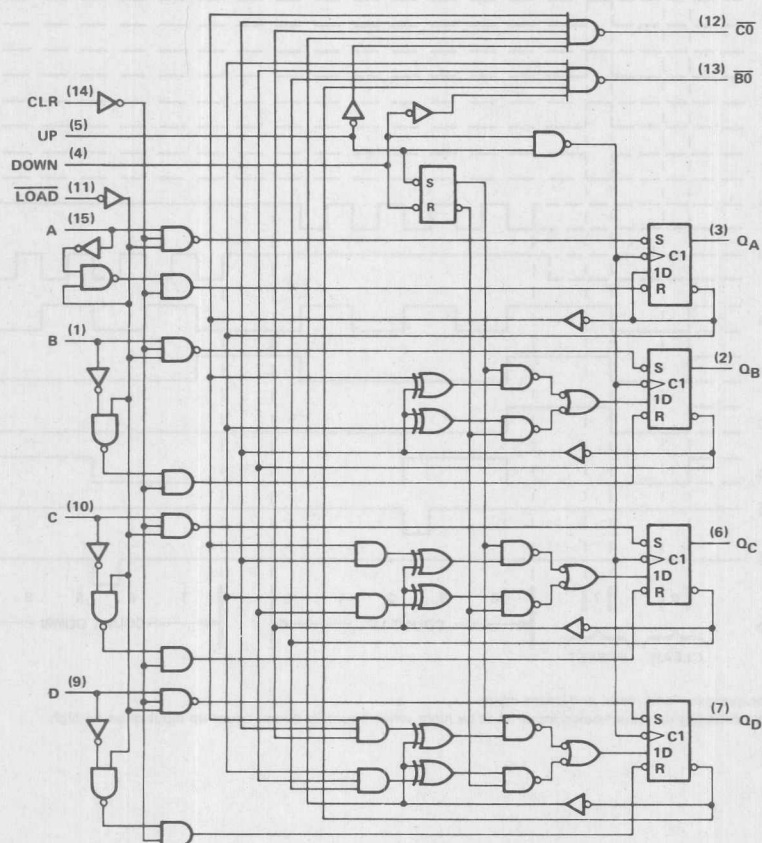
HCMOS DEVICES

**TYPES SN54HC193, SN74HC193**  
**SYNCHRONOUS 4-BIT UP/DOWN BINARY COUNTERS (DUAL CLOCK WITH CLEAR)**

**'HC193 logic symbol**



**'HC193 logic diagrams (positive logic)**



Pin numbers shown are for J and N packages.

**TYPES SN54HC192, SN74HC192**  
**SYNCHRONOUS 4-BIT UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)**

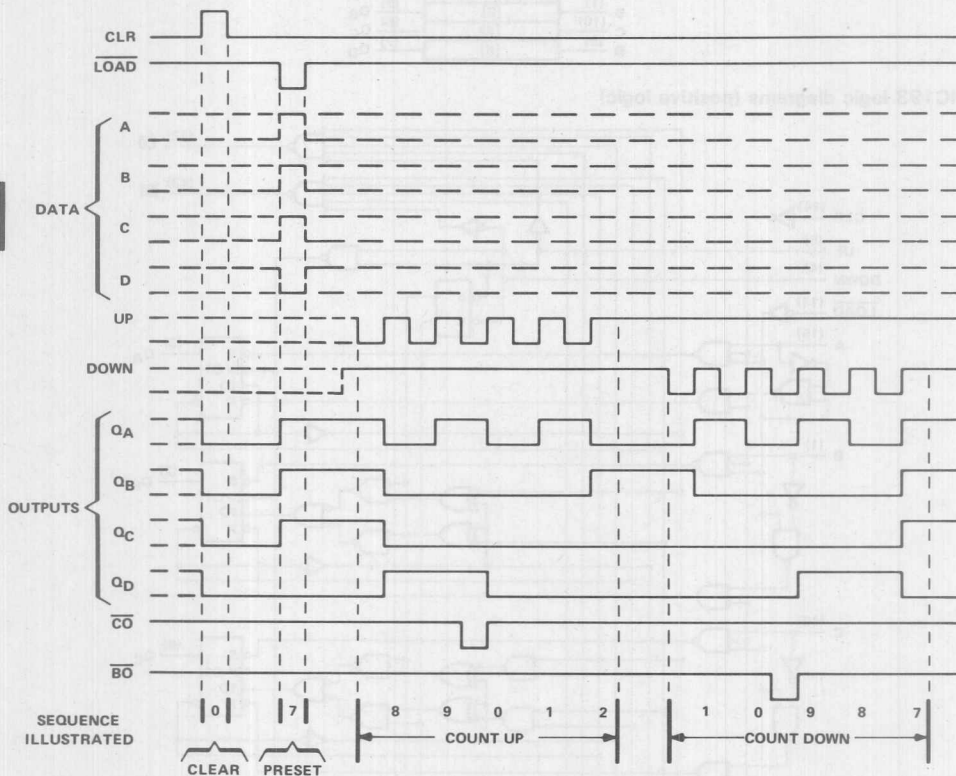
**'HC192 typical clear, load, and count sequence**

Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to BCD seven.
3. Count up to eight, nine, carry, zero, one, and two.
4. Count down to one, zero, borrow, nine, eight, and seven.

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HC MOS DEVICES



NOTES: A. Clear overrides load, data, and count inputs.

B. When counting up, count-down input must be high; when counting down, count-up input must be high.

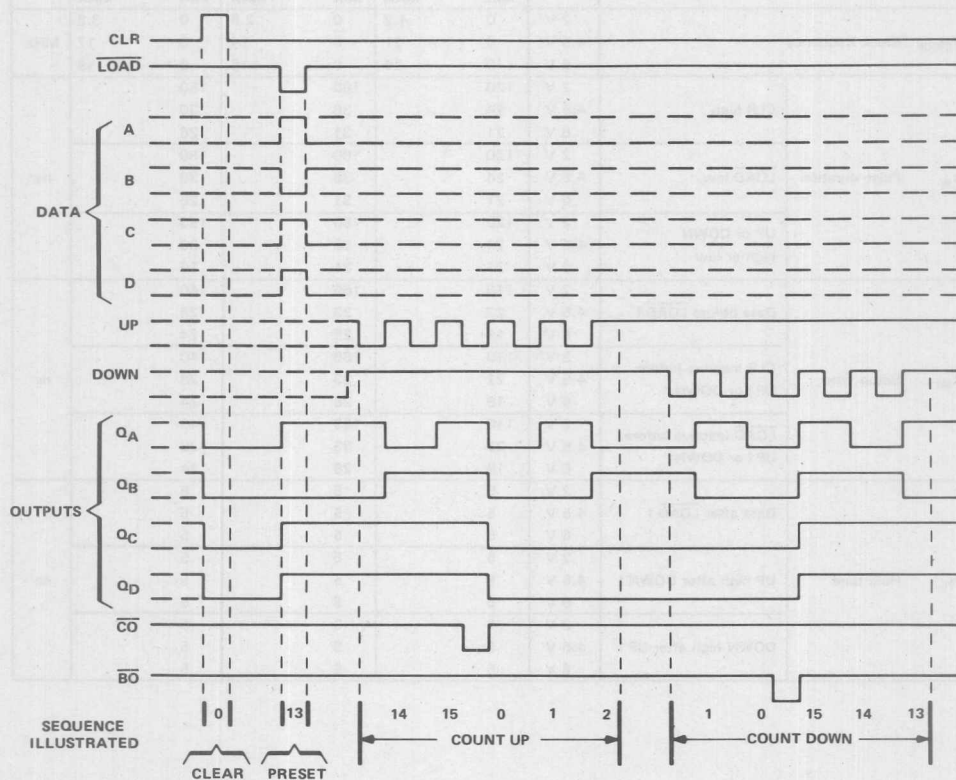


# **TYPES SN54HC193, SN74HC193** **SYNCHRONOUS 4-BIT UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)**

## **'HC193 typical clear, load, and count sequences**

Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to binary thirteen.
3. Count up to fourteen, fifteen, carry, zero, one, and two.
4. Count down to one, zero, borrow, fifteen, fourteen, and thirteen.



NOTES: A. Clear overrides load, data, and count inputs.

B. When counting up, count-down input must be high; when counting down, count-up input must be high.

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HCMOS DEVICES

**TYPES SN54HC192, SN54HC193  
SN74HC192, SN74HC193  
SYNCHRONOUS 4-BIT UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC192 SN54HC193		SN74HC192 SN74HC193		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	4.2	0	2.8	0	3.3	MHz
		4.5 V	0	21	0	14	0	17	
		6 V	0	24	0	16	0	19	
t <sub>w</sub>	CLR high	2 V	120		180		150		ns
		4.5 V	24		36		30		
		6 V	21		31		26		
	LOAD low	2 V	120		180		150		
		4.5 V	24		36		30		
		6 V	21		31		26		
	UP or DOWN high or low	2 V	120		180		150		
		4.5 V	24		36		30		
		6 V	21		31		26		
t <sub>su</sub>	Data before LOAD ↑	2 V	110		165		140		ns
		4.5 V	22		33		28		
		6 V	19		28		24		
	CLR inactive before UP ↑ or DOWN ↑	2 V	110		165		140		
		4.5 V	22		33		28		
		6 V	19		28		24		
	LOAD inactive before UP ↑ or DOWN ↑	2 V	110		165		140		
		4.5 V	22		33		28		
		6 V	19		28		24		
t <sub>h</sub>	Data after LOAD ↑	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		
	UP high after DOWN ↑	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		
	DOWN high after UP ↑	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		

3

HC MOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC192 SN54HC193		SN74HC192 SN74HC193		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	4.2	8		2.8		3.3		MHz
			4.5 V	21	55		14		17		
			6 V	24	60		16		19		
$t_{pd}$	UP	$\overline{CO}$	2 V		75	165		250		205	ns
			4.5 V		24	33		50		41	
			6 V		20	28		43		35	
$t_{pd}$	DOWN	$\overline{BO}$	2 V		75	165		250		205	ns
			4.5 V		24	33		50		41	
			6 V		20	28		43		35	
$t_{pd}$	UP or DOWN	Any Q	2 V		190	250		375		315	ns
			4.5 V		40	50		75		63	
			6 V		35	43		64		54	
$t_{pd}$	$\overline{LOAD}$	Any Q	2 V		190	260		390		325	ns
			4.5 V		40	52		78		65	
			6 V		35	44		66		55	
$t_{PHL}$	CLR	Any Q	2 V		170	240		360		300	ns
			4.5 V		36	48		72		60	
			6 V		31	41		61		51	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES

# STANDARD 8-BIT WINDOW COMPARISONS (DATA CLIP WITH CLAMP) STANDARD 8-BIT WINDOW COMPARISONS (DATA CLIP WITH CLAMP) STANDARD 8-BIT WINDOW COMPARISONS (DATA CLIP WITH CLAMP)

Switching characteristics over recommended operating free air temperature range (unless otherwise noted).  $C_L = 50$  pF (see Note 1).

PARAMETER	SYMBOL	UNIT	T <sub>A</sub> = 25 °C		T <sub>A</sub> = 0 °C		T <sub>A</sub> = 55 °C		TEST CONDITIONS
			MIN	MAX	MIN	MAX	MIN	MAX	
Propagation delay	$t_{PLH}$	ns	1.5	2.5	1.5	2.5	1.5	2.5	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Setup time	$t_{SU}$	ns	0	0	0	0	0	0	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Hold time	$t_{H}$	ns	0	0	0	0	0	0	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Output delay	$t_{ODT}$	ns	1.5	2.5	1.5	2.5	1.5	2.5	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Power dissipation	$P_D$	mW	100	100	100	100	100	100	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Static power dissipation	$P_{SD}$	mW	10	10	10	10	10	10	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Dynamic power dissipation	$P_{DD}$	mW	10	10	10	10	10	10	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Switching power dissipation	$P_{SW}$	mW	10	10	10	10	10	10	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Operating power dissipation	$P_{OP}$	mW	10	10	10	10	10	10	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω
Power dissipation per gate	$P_{DG}$	mW/gate	10	10	10	10	10	10	V <sub>DD</sub> = 5.0V, V <sub>SS</sub> = 0V, Z <sub>L</sub> = 100Ω

NOTE 1: The test circuit and test conditions are shown in Figure 1.

3

HCMOS DEVICES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Parallel Inputs and Outputs
- Four Operating Modes:
  - Synchronous Parallel Load
  - Right Shift
  - Left Shift
  - Do Nothing
- Positive Edge-Triggered Clocking
- Direct Overriding Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These bidirectional shift registers are designed to incorporate virtually all of the features a system designer may want in a shift register. The circuit features parallel inputs, parallel outputs, right-shift and left-shift inputs, operating-mode-control inputs, and a direct overriding clear line. The register has four distinct modes of operation, namely:

- Parallel (broadside) load
- Shift right (in the direction  $Q_A$  toward  $Q_D$ )
- Shift left (in the direction  $Q_D$  toward  $Q_A$ )
- Inhibit clocking (do nothing)

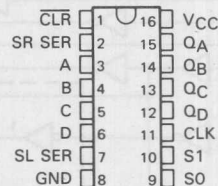
Synchronous parallel loading is accomplished by applying the four bits of data and taking both mode control inputs,  $S_0$  and  $S_1$ , high. The data are loaded into the associated flip-flops and appear at the outputs after the positive transition of the clock input. During loading, serial data flow is inhibited.

Shift right is accomplished synchronously with the rising edge of the clock pulse when  $S_0$  is high and  $S_1$  is low. Serial data for this mode is entered at the shift-right data input. When  $S_0$  is low and  $S_1$  is high, data shifts left synchronously and new data is entered at the shift-left serial input.

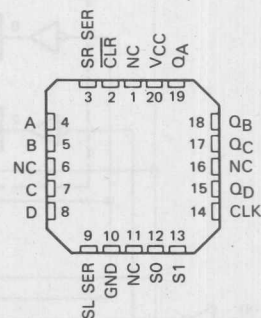
Clocking of the shift register is inhibited when both mode control inputs are low.

The SN54HC194 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC194 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC194 ... J PACKAGE  
SN74HC194 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

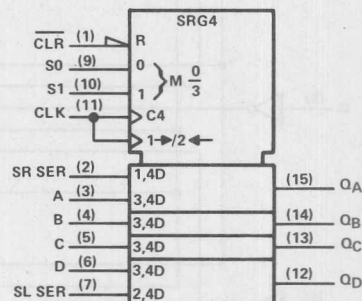


SN54HC194 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

**logic symbol**



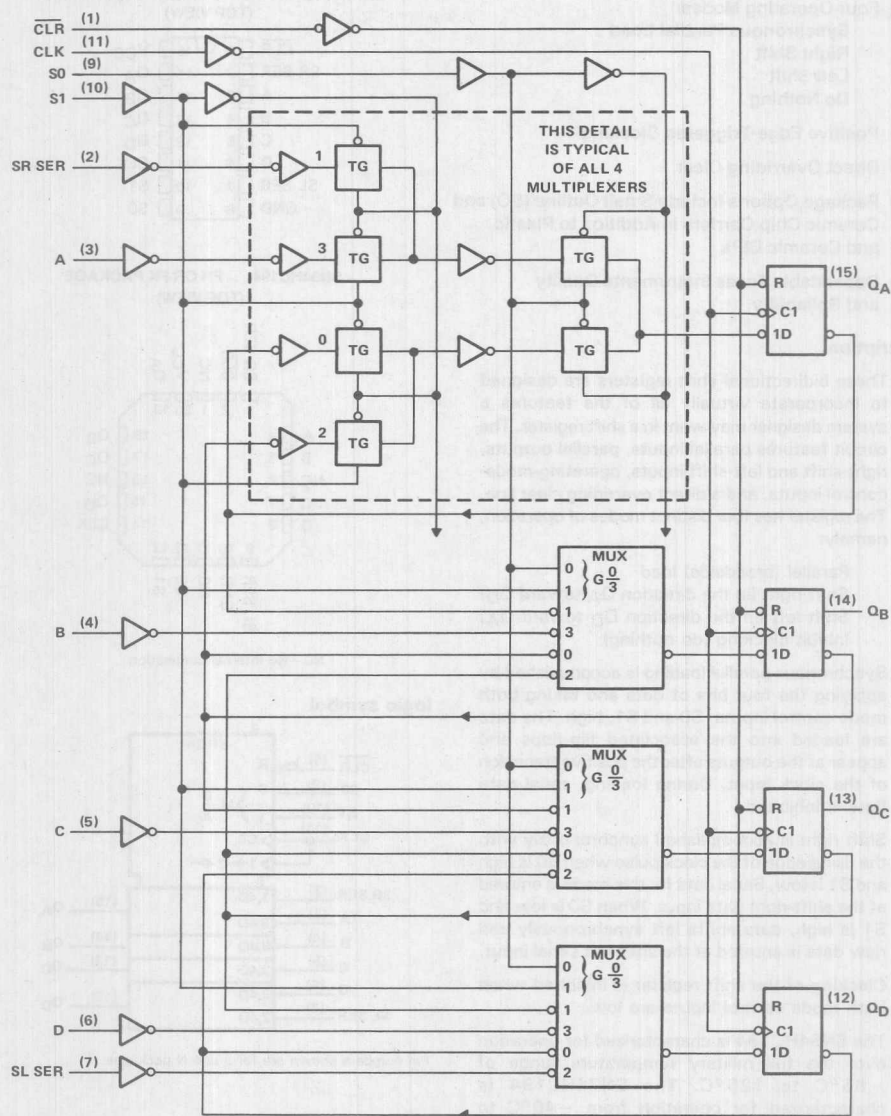
Pin numbers shown are for J and N packages.

3

HC MOS DEVICES

# **TYPES SN54HC194, SN54HC194** **4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

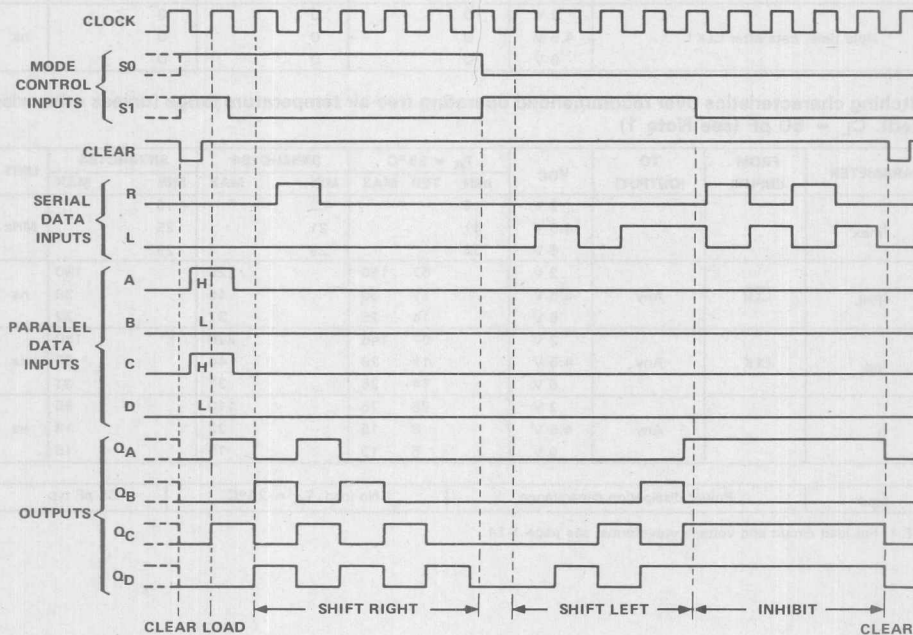


# **TYPES SN54HC194, SN74HC194** **4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

**FUNCTION TABLE**

CLEAR	MODE		CLOCK	INPUTS				OUTPUTS			
				SERIAL		PARALLEL		Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>
	S1	S0		LEFT	RIGHT	A	B	C	D		
L	X	X	X	X	X	X	X	X	X	L	L
H	X	X	L	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>D0</sub>
H	H	H	↑	X	X	a	b	c	d	a	d
H	L	H	↑	X	H	X	X	X	X	H	Q <sub>Cn</sub>
H	L	H	↑	X	L	X	X	X	X	L	Q <sub>Cn</sub>
H	H	L	↑	H	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Dn</sub>
H	H	L	↑	L	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Dn</sub>
H	L	L	X	X	X	X	X	X	X	Q <sub>An</sub>	Q <sub>D0</sub>

typical clear, load, right-shift, left-shift, inhibit, and clear sequences



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

3

HC MOS DEVICES

# **TYPES SN54HC194, SN74HC194** **4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC194		SN74HC194		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		6	0	4.2	0	5	MHz
		4.5 V	0		31	0	21	0	25	
		6 V	0		36	0	25	0	29	
t <sub>w</sub>	Pulse duration	2 V	80			120		100		ns
		4.5 V	16			24		20		
		6 V	14			20		17		
	CLR low	2 V	80			120		100		
		4.5 V	16			24		20		
		6 V	14			20		17		
t <sub>su</sub>	Setup time, any input before CLK ↑	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			26		21		
t <sub>h</sub>	Hold time, data after CLK ↑	2 V	0			0		0		ns
		4.5 V	0			0		0		
		6 V	0			0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC194		SN74HC194		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6			4.2		5		MHz
			4.5 V	31			21		25		
			6 V	36			25		29		
t <sub>PHL</sub>	CLR	Any	2 V	67 150			225		190		ns
			4.5 V	17 30			45		38		
			6 V	14 26			37		32		
t <sub>pd</sub>	CLK	Any	2 V	67 145			220		180		ns
			4.5 V	17 29			44		36		
			6 V	14 25			37		31		
t <sub>t</sub>		Any	2 V	28 75			110		95		ns
			4.5 V	8 15			22		19		
			6 V	6 13			19		16		
C <sub>pd</sub>	Power dissipation capacitance			No load, T <sub>A</sub> = 25°C						65 pF typ	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC195, SN74HC195 4-BIT PARALLEL-ACCESS SHIFT REGISTERS

D2684, DECEMBER 1982 — REVISED MARCH 1984

- Synchronous Parallel Load
- Positive-Edge-Triggered Clocking
- J and  $\bar{K}$  Inputs to First Stage
- Complementary Outputs from Last Stage
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

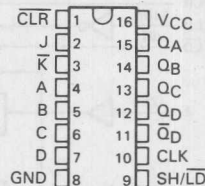
These 4-bit registers feature parallel inputs, parallel outputs, J- $\bar{K}$  serial inputs, shift/load control input, and a direct overriding clear. The registers have two modes of operation: parallel (broadside) load, and shift (in the direction  $Q_A$  and  $Q_D$ ).

Parallel loading is accomplished by applying the four bits of data and taking the shift/load control input low. The data is loaded into the associated flip-flop and appears at the outputs after the positive transition of the clock input. During loading, serial data flow is inhibited.

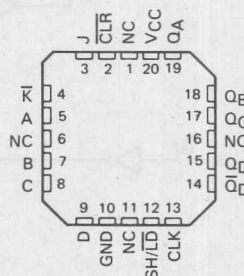
Shifting is accomplished synchronously when the shift/load control input is high. Serial data for this mode is entered at the J- $\bar{K}$  inputs. These inputs permit the first stage to perform as a J- $\bar{K}$ , D-, or T-type flip-flop as shown in the function table.

The SN54HC195 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC195 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC195... J PACKAGE  
SN74HC195... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

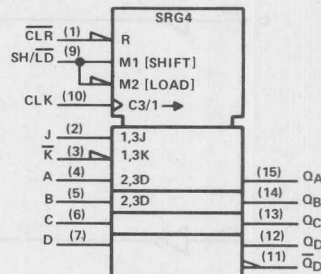


SN54HC195... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



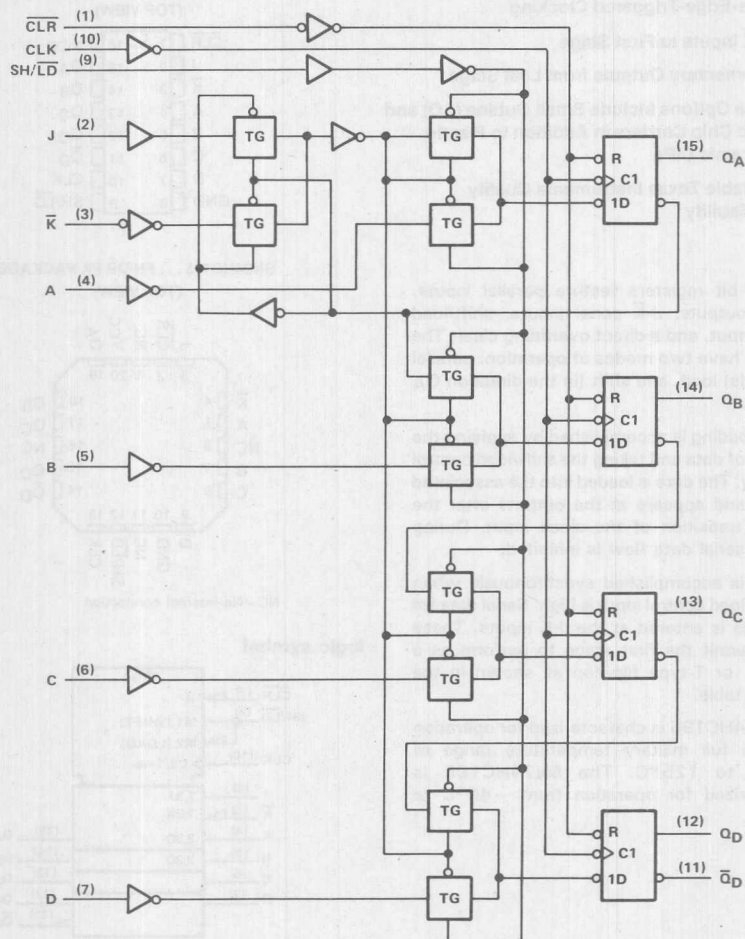
Pin numbers shown are for J and N packages.

3

HC MOS DEVICES

**TYPES SN54HC195, SN74HC195**  
**4-BIT PARALLEL-ACCESS SHIFT REGISTERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

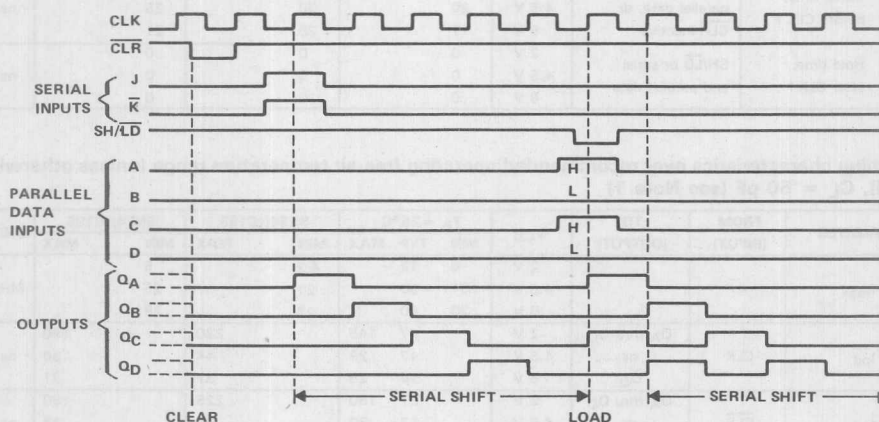
HCMOS DEVICES

# TYPES SN54HC195, SN74HC195 4-BIT PARALLEL-ACCESS SHIFT REGISTERS

FUNCTION TABLE

			INPUTS								OUTPUTS				
$\overline{\text{CLR}}$	$\text{SH}/\overline{\text{LD}}$	CLK	SERIAL		PARALLEL						$Q_A$	$Q_B$	$Q_C$	$Q_D$	$\overline{Q_D}$
			J	$\overline{K}$	A	B	C	D			a	b	c	d	$\overline{d}$
L	X	X	X	X	X	X	X	X			L	L	L	L	H
H	L	$\uparrow$	X	X	a	b	c	d			$Q_{A0}$	$Q_{B0}$	$Q_{C0}$	$Q_{D0}$	$\overline{Q_{D0}}$
H	H	L	X	X	X	X	X	X			$Q_{A0}$	$Q_{A0}$	$Q_{Bn}$	$Q_{Cn}$	$\overline{Q_{Cn}}$
H	H	$\uparrow$	L	H	X	X	X	X			$Q_{A0}$	$Q_{A0}$	$Q_{Bn}$	$Q_{Cn}$	$\overline{Q_{Cn}}$
H	H	$\uparrow$	L	L	X	X	X	X			L	$Q_{An}$	$Q_{Bn}$	$Q_{Cn}$	$\overline{Q_{Cn}}$
H	H	$\uparrow$	H	H	X	X	X	X			H	$Q_{An}$	$Q_{Bn}$	$Q_{Cn}$	$\overline{Q_{Cn}}$
H	H	$\uparrow$	H	L	X	X	X	X			$\overline{Q_{An}}$	$Q_{An}$	$Q_{Bn}$	$Q_{Cn}$	$\overline{Q_{Cn}}$

typical clear, shift, and load sequences



absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

3

HCMOS DEVICES

# **TYPES SN54HC195, SN74HC195** **4-BIT PARALLEL-ACCESS SHIFT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC195		SN74HC195		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		6	0	4.2	0	5	MHz
		4.5 V	0		31	0	21	0	25	
		6 V	0		36	0	25	0	29	
t <sub>w</sub>	Pulse duration	2 V	80			120		100		ns
		4.5 V	16			24		20		
		6 V	14			20		17		
	CL <sub>R</sub> low	2 V	80			120		100		
		4.5 V	16			24		20		
		6 V	14			20		17		
t <sub>su</sub>	Setup time, before CLK ↑	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			26		21		
t <sub>h</sub>	Hold time, after CLK ↑	2 V	0			0		0		ns
		4.5 V	0			0		0		
		6 V	0			0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC195		SN74HC195		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	12		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		29		
t <sub>pd</sub>	CLK	Q <sub>A</sub> thru Q <sub>D</sub> or Q̄ <sub>D</sub>	2 V		67	145		220		180	ns
			4.5 V		17	29		44		36	
			6 V		14	25		37		31	
t <sub>pd</sub>	CL <sub>R</sub>	Q <sub>A</sub> thru Q <sub>D</sub> or Q̄ <sub>D</sub>	2 V		67	150		225		190	ns
			4.5 V		17	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	65 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES



**TYPES SN54HC237, SN74HC237  
3-LINE TO 8-LINE DECODERS/DEMULPLEXERS  
WITH ADDRESS LATCHES**

D2804, MARCH 1984

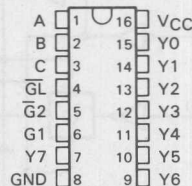
- Combines Decoder and 3-Bit Address Latch
- Incorporates 2 Output Enables to Simplify Cascading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

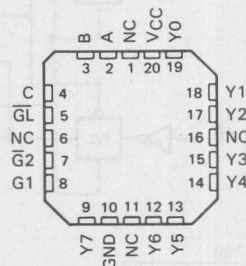
The 'HC237 is a three-line to eight-line decoder/demultiplexer with latches on the three address inputs. When the latch-enable ( $\overline{GL}$ ) is low, the 'HC237 acts as a decoder/demultiplexer. When  $\overline{GL}$  goes from low to high, the address present at the select inputs (A, B, and C) is stored in the latches. Further address changes are ignored as long as  $\overline{GL}$  remains high. The output enable controls, G1 and  $\overline{G2}$ , control the outputs independently of the select or latch-enable inputs. All of the outputs are forced high if G1 is low or  $\overline{G2}$  is high. The 'HC237 is ideally suited for implementing glitch-free decoders in strobed (stored-address) applications in bus-oriented systems.

The SN54HC237 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC237 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC237 ... J PACKAGE  
SN74HC237 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

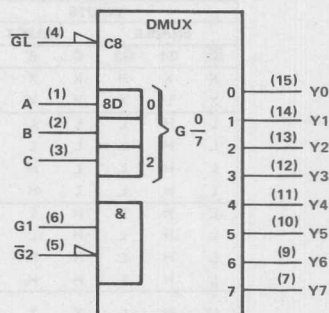
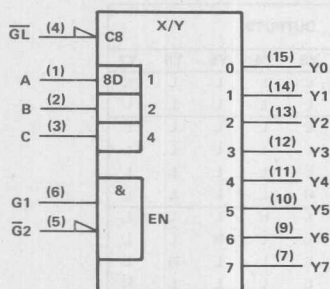


SN54HC237 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

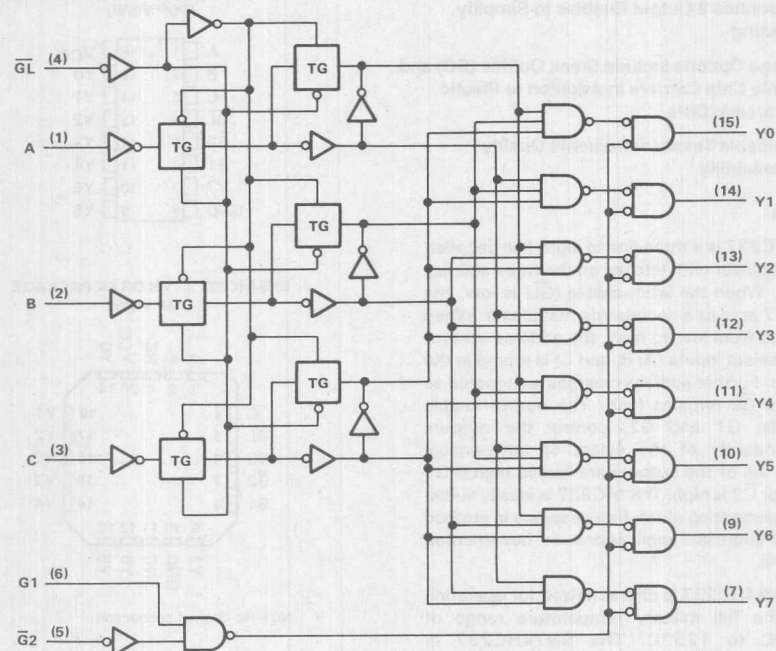
**logic symbols (alternatives)**



Pin numbers shown are for J and N packages.

**TYPES SN54HC237, SN74HC237**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

FUNCTION TABLE

INPUTS						OUTPUTS							
ENABLE			SELECT										
$\overline{G1}$	G1	$\overline{G2}$	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	L	L	L	L	L	L	L	L
X	L	X	X	X	X	L	L	L	L	L	L	L	L
L	H	L	L	L	L	H	L	L	L	L	L	L	L
L	H	L	L	L	H	L	H	L	L	L	L	L	L
L	H	L	L	H	L	L	L	H	L	L	L	L	L
L	H	L	L	H	H	L	L	L	H	L	L	L	L
L	H	L	H	L	L	L	L	L	L	H	L	L	L
L	H	L	H	L	H	L	L	L	L	L	H	L	L
L	H	L	H	H	L	L	L	L	L	L	L	H	L
L	H	L	H	H	H	L	L	L	L	L	L	L	H
H	H	L	X	X	X	Outputs corresponding to stored address, L; all others, H							

# **TYPES SN54HC237, SN74HC237** **3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC237		SN74HC237		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, $\overline{\text{GL}}$ low	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, A, B, and C before $\overline{\text{GL}}$ ↑	2 V	75		115		95		ns
	4.5 V	15		23		19		
	6 V	13		20		16		
t <sub>h</sub> Hold time, A, B, and C after $\overline{\text{GL}}$ ↑	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF, (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC237		SN74HC237		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, C	Any	2 V		91	190		285		240	ns
			4.5 V		23	38		57		48	
			6 V		17	32		48		41	
t <sub>pd</sub>	$\overline{\text{G2}}$	Any	2 V		66	145		220		181	ns
			4.5 V		18	29		44		36	
			6 V		13	25		37		31	
t <sub>pd</sub>	G1	Any	2 V		68	145		220		181	ns
			4.5 V		18	29		44		36	
			6 V		14	25		37		31	
t <sub>pd</sub>	$\overline{\text{GL}}$	Any	2 V		92	190		285		240	ns
			4.5 V		24	38		57		48	
			6 V		19	32		48		41	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES

Maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 3-13

Timing requirements over recommended operating free-air temperature range unless otherwise noted

PARAMETER	SYMBOL	UNITS	T <sub>A</sub> = 25°C		T <sub>A</sub> = 55°C	T <sub>A</sub> = 75°C
			MIN	TYP	MAX	MIN
Input capacitance	C <sub>i</sub>	pF	10	15	20	25
Output capacitance	C <sub>o</sub>	pF	10	15	20	25
Propagation delay	t <sub>pd</sub>	ns	10	15	20	25
Settling time	t <sub>s</sub>	ns	10	15	20	25
Power dissipation	P <sub>D</sub>	mW	10	15	20	25

3

HCMOS DEVICES

Timing characteristics over recommended operating free-air temperature range unless otherwise noted. C<sub>L</sub> = 50 pF, rise time = 10 ns

PARAMETER	SYMBOL	UNITS	T <sub>A</sub> = 25°C		T <sub>A</sub> = 55°C	T <sub>A</sub> = 75°C
			MIN	TYP	MAX	MIN
Input capacitance	C <sub>i</sub>	pF	10	15	20	25
Output capacitance	C <sub>o</sub>	pF	10	15	20	25
Propagation delay	t <sub>pd</sub>	ns	10	15	20	25
Settling time	t <sub>s</sub>	ns	10	15	20	25
Power dissipation	P <sub>D</sub>	mW	10	15	20	25

10	15	20	25
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NOTE 1: For test circuit, see Figure 10-1.

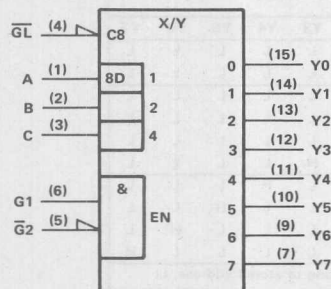
- Inputs are TTL-Voltage Compatible
- Combines Decoder and 3-Bit-Address Latch
- Incorporates 2 Output Enables to Simplify Cascading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

The 'HCT237 is a three-line to eight-line decoder/demultiplexer with latches on the three address inputs. When the latch-enable input ( $\overline{GL}$ ) is low, the 'HCT237 acts as a decoder/demultiplexer. When  $\overline{GL}$  goes from low to high, the address present at the select inputs (A, B, and C) is stored in the latches. Further address changes are ignored as long as  $\overline{GL}$  remains high. The output enable controls, G1 and  $\overline{G2}$ , control the outputs independently of the select or latch-enable inputs. All of the outputs are forced high if G1 is low or  $\overline{G2}$  is high. The 'HCT237 is ideally suited for implementing glitch-free decoders in strobed (stored-address) applications in bus-oriented systems.

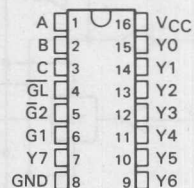
The SN54HCT237 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT237 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

#### logic symbols (alternatives)

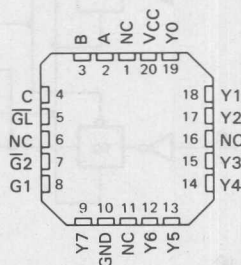


Pin numbers shown are for J and N packages.

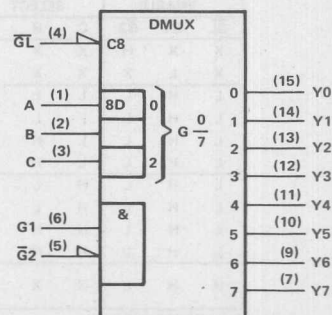
SN54HCT237 ... J PACKAGE  
SN74HCT237 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT237 ... FH OR FK PACKAGE  
(TOP VIEW)

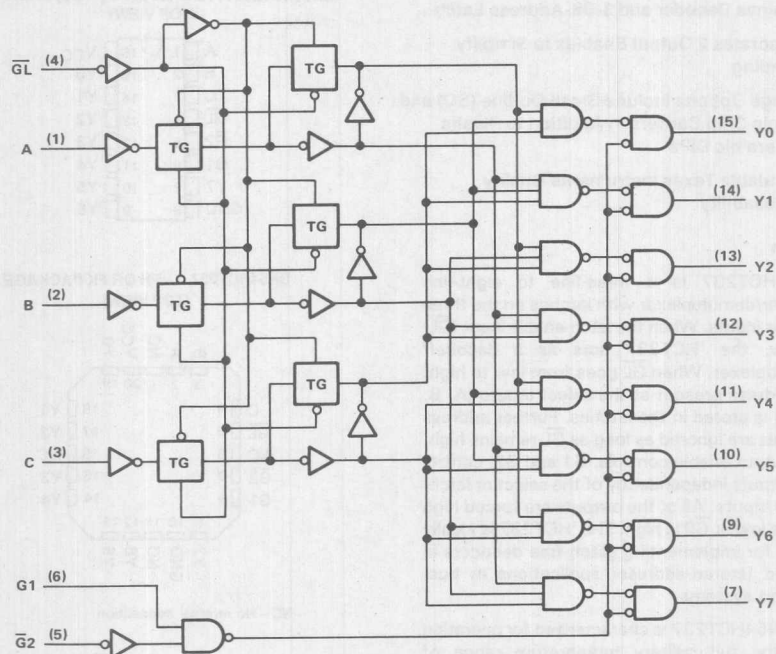


NC—No internal connection



**TYPES SN54HCT237, SN74HCT237**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

FUNCTION TABLE

INPUTS						OUTPUTS							
ENABLE			SELECT										
$\overline{G1}$	G1	$\overline{G2}$	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	X	H	X	X	X	L	L	L	L	L	L	L	L
X	L	X	X	X	X	L	L	L	L	L	L	L	L
L	H	L	L	L	L	H	L	L	L	L	L	L	L
L	H	L	L	L	H	L	H	L	L	L	L	L	L
L	H	L	L	H	L	L	L	H	L	L	L	L	L
L	H	L	L	H	H	L	L	L	H	L	L	L	L
L	H	L	H	L	L	L	L	L	L	H	L	L	L
L	H	L	H	L	H	L	L	L	L	L	H	L	L
L	H	L	H	H	L	L	L	L	L	L	L	H	L
L	H	L	H	H	H	L	L	L	L	L	L	L	H
H	H	L	X	X	X	Output corresponding to stored address, L; all others, H							



# TYPES SN54HCT237, SN74HCT237 3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VIII, page 2-15.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT237		SN74HCT237		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>W</sub> Pulse duration, $\overline{GL}$ low	4.5 V	26		39		33		ns
	5.5 V	23		35		30		
t <sub>su</sub> Setup time, A, B, and C before $\overline{GL}$ ↑	4.5 V	15		23		19		ns
	5.5 V	14		21		17		
t <sub>h</sub> Hold time, A, B, and C before $\overline{GL}$ ↑	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT237		SN74HCT237		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, C	Any	4.5 V		24	38		57		48	ns
			5.5 V		20	34		51		43	
t <sub>pd</sub>	$\overline{G2}$	Any	4.5 V		19	29		44		36	ns
			5.5 V		16	26		40		32	
t <sub>pd</sub>	G1	Any	4.5 V		19	29		44		36	ns
			5.5 V		16	26		40		32	
t <sub>pd</sub>	$\overline{GL}$	Any	4.5 V		29	42		63		52	ns
			5.5 V		25	36		57		47	
t <sub>t</sub>		Any	4.5 V		12	15		22		19	ns
			5.5 V		11	14		20		17	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

Maximum output current is limited by the output resistance and the load capacitance.

See Table 1 and page 3-17.

Output resistance is given by the output resistance of the output stage and the load capacitance.

Output	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance
1	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100

Output resistance is given by the output resistance of the output stage and the load capacitance. (C<sub>L</sub> = 50 pF, see Table 1)

Output	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance
1	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100
8	100	100	100	100	100	100	100

Output	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance	Output resistance
1	100	100	100	100	100	100	100

Output resistance is given by the output resistance of the output stage and the load capacitance.

3

HCMOS DEVICES

- Designed Specifically for High-Speed Memory Decoders and Data Transmission Systems
- Incorporates 3 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

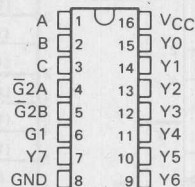
### description

The 'HC238 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast enable circuit, the delay times of this decoder and the enable time of the memory are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

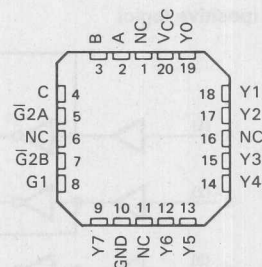
The conditions at the binary select inputs and the three enable inputs select one of eight input lines. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented without external inverters and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The SN54HC238 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC238 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC238 ... J PACKAGE  
SN74HC238 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



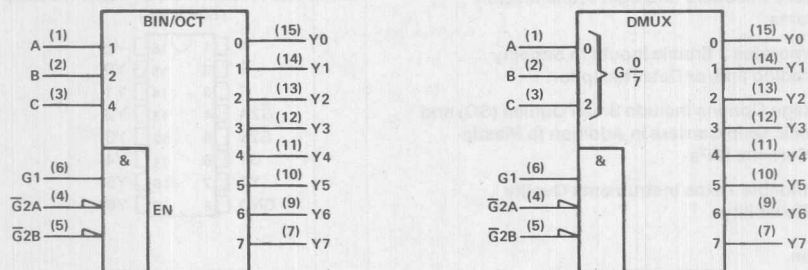
SN54HC238 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

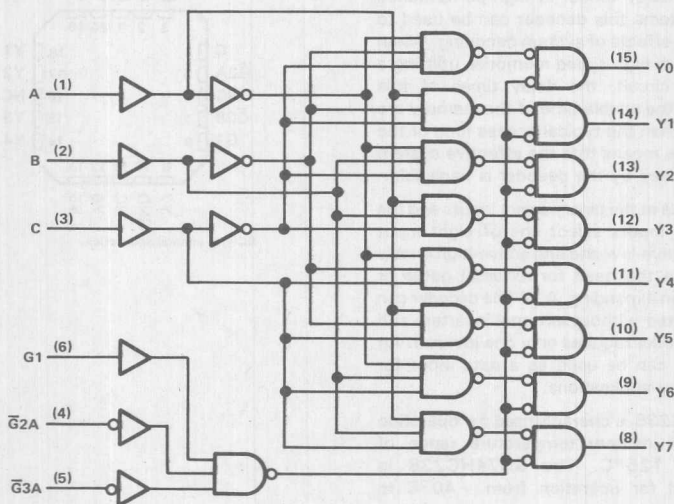
# **TYPES SN54HC238, SN74HC238** **3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

## logic symbols (alternatives)



Pin numbers shown are for J and N packages.

## logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

**TYPES SN54HC238, SN74HC238**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

FUNCTION TABLE

ENABLE INPUTS			SELECT INPUTS			OUTPUTS							
G1	G2A	G2B	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	X	L	L	L	L	L	L	L	L
X	X	H	X	X	X	L	L	L	L	L	L	L	L
L	X	X	X	X	X	L	L	L	L	L	L	L	L
H	L	L	L	L	L	H	L	L	L	L	L	L	L
H	L	L	L	L	H	L	H	L	L	L	L	L	L
H	L	L	L	H	L	L	L	H	L	L	L	L	L
H	L	L	L	H	H	L	L	L	H	L	L	L	L
H	L	L	H	L	L	L	L	L	L	H	L	L	L
H	L	L	H	L	H	L	L	L	L	L	H	L	L
H	L	L	H	H	L	L	L	L	L	L	L	H	L
H	L	L	H	H	H	L	L	L	L	L	L	L	H

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range  
(unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC238		SN74HC238		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	Any	2 V		67	180		270		225	ns
			4.5 V		20	36		54		45	
			6 V		15	31		46		38	
$t_{pd}$	Enable	Any	2 V		60	155		235		195	ns
			4.5 V		17	31		47		39	
			6 V		13	26		40		33	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES





- Inputs are TTL-Voltage Compatible
- Designed Specifically for High-Speed Memory Decoders and Data Transmission Systems
- Incorporates 3 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

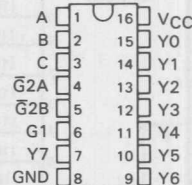
**description**

The 'HCT238 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast enable circuit, the delay times of this decoder and the enable time of the memory are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

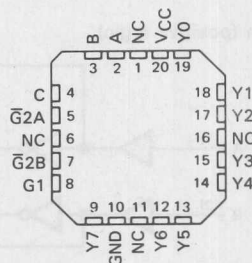
The conditions at the binary select inputs and the three enable inputs select one of eight input lines. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. A 24-line decoder can be implemented without external inverters and a 32-line decoder requires only one inverter. An enable input can be used as a data input for demultiplexing applications.

The SN54HCT238 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT238 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT238 ... J PACKAGE  
SN74HCT238 ... J OR N OR D(= SO) PACKAGE  
(TOP VIEW)



SN54HCT238 ... FH OR FK PACKAGE  
(TOP VIEW)



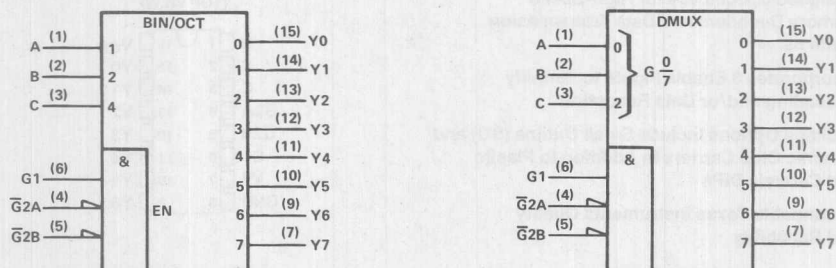
NC—No internal connection

**3**

**HCMOS DEVICES**

# **TYPES SN54HCT238, SN74HCT238** **3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

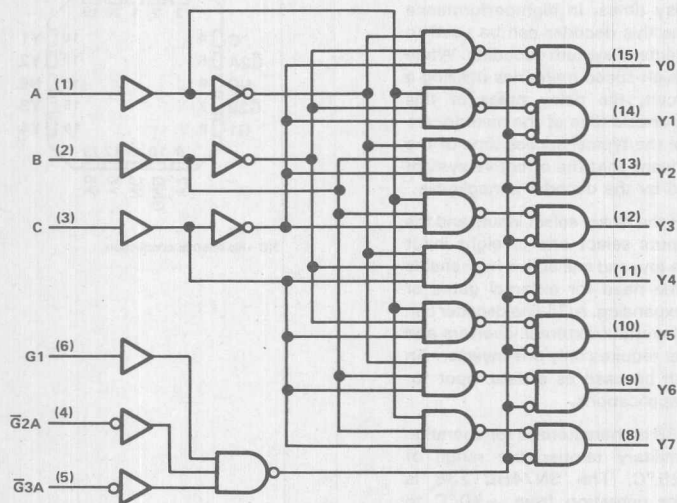
## logic symbols (alternatives)



Pin numbers shown are for J and N packages.

3

## logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**TYPES SN54HCT238, SN74HCT238**  
**3-LINE TO 8-LINE DECODERS/DEMULTIPLEXERS**

FUNCTION TABLE

ENABLE INPUTS			SELECT INPUTS			OUTPUTS							
G1	G2A	G2B	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	X	L	L	L	L	L	L	L	L
X	X	H	X	X	X	L	L	L	L	L	L	L	L
L	X	X	X	X	X	L	L	L	L	L	L	L	L
H	L	L	L	L	L	H	L	L	L	L	L	L	L
H	L	L	L	L	H	L	H	L	L	L	L	L	L
H	L	L	L	H	L	L	L	H	L	L	L	L	L
H	L	L	L	H	H	L	L	L	H	L	L	L	L
H	L	L	H	L	L	L	L	L	L	H	L	L	L
H	L	L	H	L	H	L	L	L	L	L	H	L	L
H	L	L	H	H	L	L	L	L	L	L	L	H	L
H	L	L	H	H	H	L	L	L	L	L	L	L	H

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VIII, page 2-15.

switching characteristics over recommended operating free-air temperature range  
(unless otherwise noted),  $C_L = 50$  pF, (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT238		SN74HCT238		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, or C	Any	4.5 V		21	36		54		45	ns
			5.5 V		18	32		49		41	
t <sub>pd</sub>	Enable	Any	4.5 V		21	33		50		42	ns
			5.5 V		17	30		45		38	
t <sub>t</sub>		Any	4.5 V		11	15		22		19	ns
			5.5 V		9	14		20		17	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	85 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

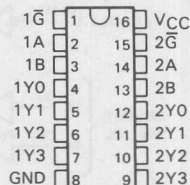
3

HCMOS DEVICES



- Designed Specifically for High-Speed Memory Decoders and Data Transmission Systems
- Incorporates 2 Enable Inputs to Simplify Cascading and/or Data Reception
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC239... J PACKAGE  
SN74HC239... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



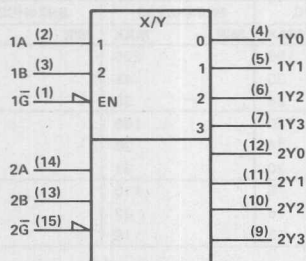
### description

The 'HC239 circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. In high-performance memory systems, this decoder can be used to minimize the effects of system decoding. When employed with high-speed memories utilizing a fast-enable circuit, the delay times of this decoder and the enable time of the memory are usually less than the typical access time of the memory. This means that the effective system delay introduced by the decoder is negligible.

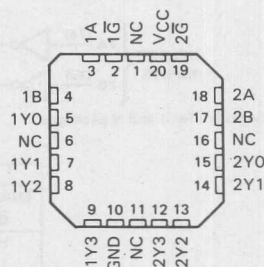
The 'HC239 is comprised of two individual two-line to four-line decoders in a single package. The active-low enable input can be used as a data line in demultiplexing applications. These decoders/demultiplexers feature fully buffered inputs, each of which represents only one normalized load to its driving circuit.

The SN54HC239 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC239 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

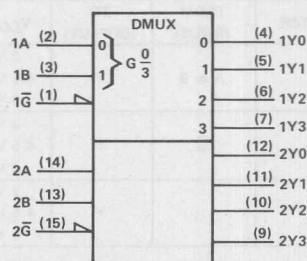
### logic symbols (alternatives)



SN54HC239... FH OR FK PACKAGE  
(TOP VIEW)



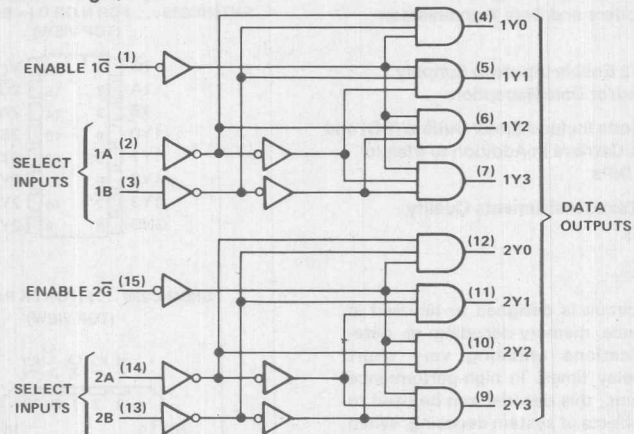
NC—No internal connection



Pin numbers shown are for J and N packages.

# TYPES SN54HC239, SN74HC239 DUAL 2-LINE TO 4-LINE DECODERS/DEMULTIPLEXERS

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

FUNCTION TABLE

INPUTS			OUTPUTS			
ENABLE	SELECT					
$\bar{G}$	B	A	Y0	Y1	Y2	Y3
H	X	X	L	L	L	L
L	L	L	H	L	L	L
L	L	H	L	H	L	L
L	H	L	L	L	H	L
L	H	H	L	L	L	H

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC239		SN74HC239		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V	62	150		225		190	ns	
			4.5 V	18	30		45		38		
			6 V	14	26		38		32		
t <sub>pd</sub>	$\overline{G}$	Y	2 V	53	120		180		150	ns	
			4.5 V	14	24		36		30		
			6 V	11	20		31		26		
t <sub>pd</sub>		Y	2 V	38	75		110		95	ns	
			4.5 V	8	15		22		19		
			6 V	6	13		19		16		
C <sub>pd</sub>	Power dissipation capacitance per decoder			No load, T <sub>A</sub> = 25°C				25 pF typ			

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



D2684, DECEMBER 1982—REVISED MARCH 1984

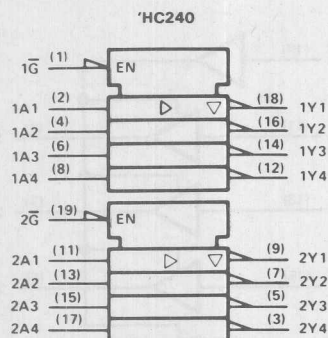
- 3-State Outputs Drive Bus Lines or Buffer Memory Address Registers
- High-Current Outputs Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

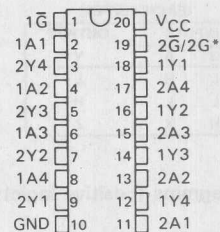
These octal buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. The designer has a choice of selected combinations of inverting and noninverting outputs, symmetrical  $\bar{G}$  (active-low output control) inputs, and complementary  $G$  and  $\bar{G}$  inputs. These devices feature high fan-out.

The SN54HC' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

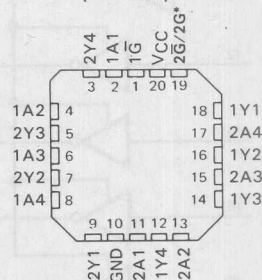
### logic symbol



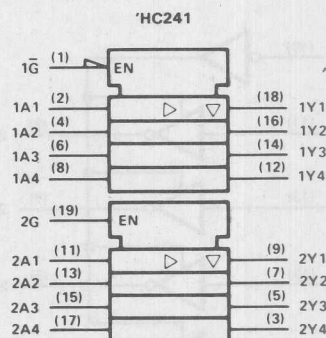
SN54HC' ... J PACKAGE  
SN74HC' ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC' ... FH OR FK PACKAGE  
(TOP VIEW)



\*2 $\bar{G}$  for 'HC240, or 2G for 'HC241



# **TYPES SN54HC240, SN54HC241, SN74HC240, SN74HC241** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

FUNCTION TABLES

**'HC240**  
(EACH BUFFER)

INPUTS		OUTPUT
G	A	Y
L	H	L
L	L	H
H	X	Z

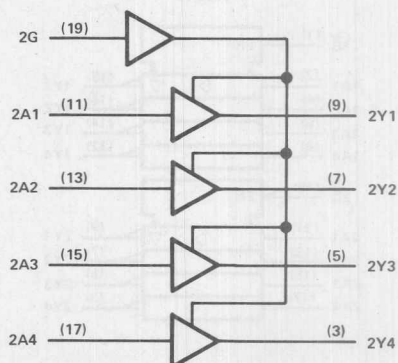
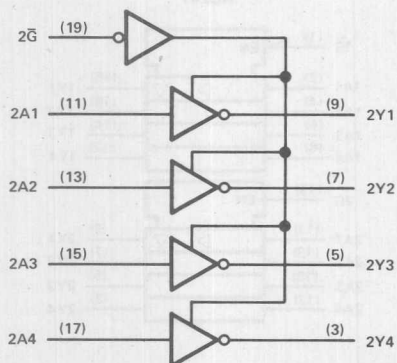
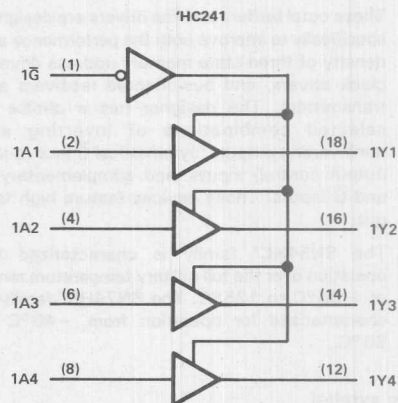
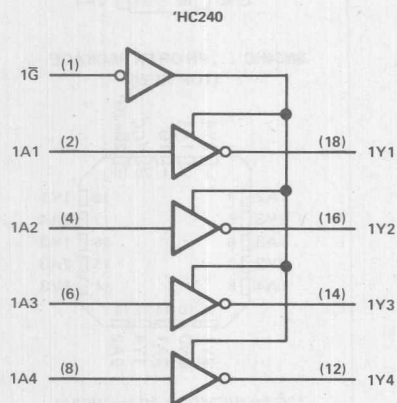
**'HC241**  
(EACH BUFFER IN FIRST SET)

INPUTS		OUTPUT
1G	1A	1Y
L	H	H
L	L	L
H	X	Z

**'HC241**  
(EACH BUFFER IN SECOND SET)

INPUTS		OUTPUT
2G	2A	2Y
H	H	H
H	L	L
L	X	Z

logic diagrams (positive logic)



# **TYPES SN54HC240, SN74HC240** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC240		SN74HC240		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		9	17		25		21	
$t_{en}$	$\bar{G}$	Y	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{dis}$	$\bar{G}$	Y	2 V		44	150		225		190	ns
			4.5 V		22	30		45		38	
			6 V		21	26		38		32	
$t_t$		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per buffer	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC240		SN74HC240		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{en}$	$\bar{G}$	Y	2 V		100	200		300		250	ns
			4.5 V		20	40		60		50	
			6 V		17	34		51		43	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HC241, SN74HC241** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC241		SN74HC241		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	2 V		39	115		170		145	ns
			4.5 V		12	23		34		29	
			6 V		11	20		29		25	
t <sub>en</sub>	$\bar{G}$ or G	Y	2 V		60	150		225		190	ns
			4.5 V		17	30		45		38	
			6 V		15	26		38		32	
t <sub>dis</sub>	$\bar{G}$ or G	Y	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		17	26		38		32	
t <sub>t</sub>		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per buffer	No load, T <sub>A</sub> = 25°C	35 pF typ
-----------------	--	--------------------------------	-----------

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC241		SN74HC241		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	2 V		50	165		245		210	ns
			4.5 V		16	33		49		42	
			6 V		14	28		42		35	
t <sub>en</sub>	$\bar{G}$ or G	Y	2 V		100	200		300		250	ns
			4.5 V		20	40		60		50	
			6 V		17	34		51		43	
t <sub>t</sub>		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT240, SN54HCT241, SN74HCT240, SN74HCT241 OCTAL BUFFERS AND LINE DRIVERS CMOS LOGIC WITH 3-STATE OUTPUTS

D2804, MARCH 1984

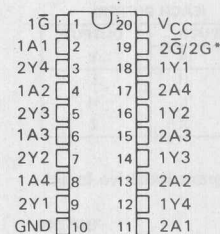
- Inputs are TTL-Voltage Compatible
- 3-State Outputs Drive Bus Lines or Buffer Memory Address Registers
- High-Current Outputs Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

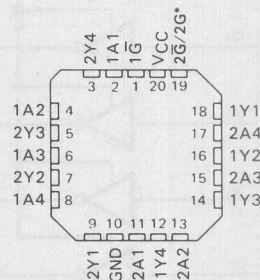
These octal buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. The designer has a choice of selected combinations of inverting and noninverting outputs, symmetrical  $\bar{G}$  (active-low output control) inputs, and complementary  $G$  and  $\bar{G}$  inputs. These devices feature high fan-out.

The SN54HCT' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT' ... J PACKAGE  
SN74HCT' ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

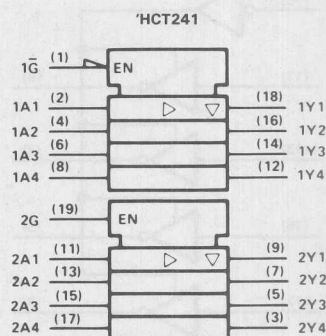
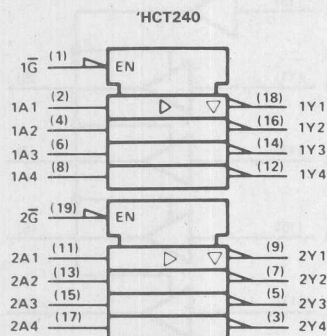


SN54HCT' ... FH OR FK PACKAGE  
(TOP VIEW)



\* $2\bar{G}$  for 'HCT240, or  $2G$  for 'HCT241

### logic symbols



# TYPES SN54HCT240, SN54HCT241, SN74HCT240, SN74HCT241 OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

FUNCTION TABLES

**'HCT240**  
(EACH BUFFER)

INPUTS		OUTPUT
$\bar{G}$	A	Y
L	H	L
L	L	H
H	X	Z

**'HCT241**  
(EACH BUFFER IN FIRST SET)

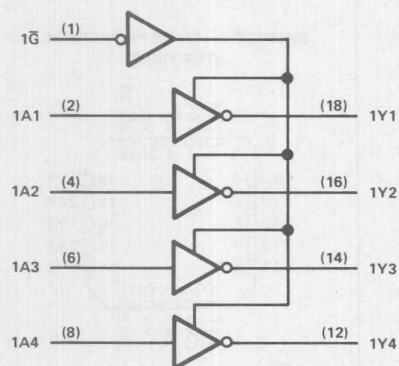
INPUTS		OUTPUT
$1\bar{G}$	1A	1Y
L	H	H
L	L	L
H	X	Z

**'HCT241**  
(EACH BUFFER IN SECOND SET)

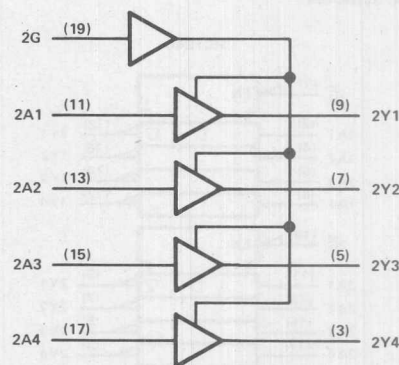
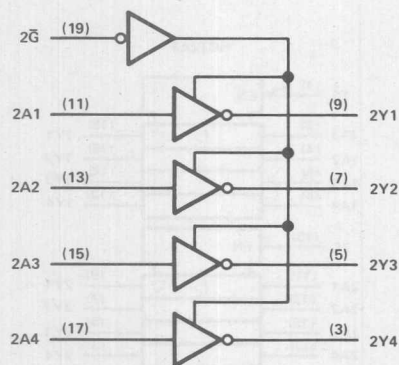
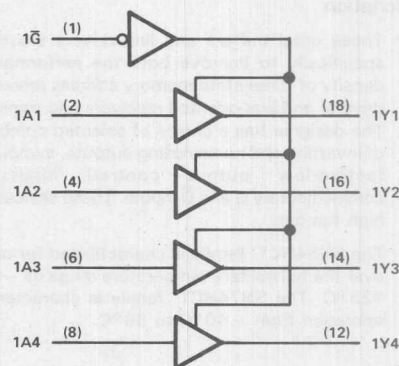
INPUTS		OUTPUT
2G	2A	2Y
H	H	H
H	L	L
L	X	Z

logic diagram (positive logic)

**'HCT240**



**'HCT241**



3  
HCMOS DEVICES



# **TYPES SN54HCT240, SN54HCT241, SN74HCT240, SN74HCT241** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics  
 See Table VII, page 2-14.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HCT240 SN54HCT241		SN74HCT240 SN74HCT241		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		13	25		37		32	ns
			5.5 V		12	23		33		29	
$t_{en}$	G or $\overline{G}$	Y	4.5 V		21	35		53		44	ns
			5.5 V		19	32		48		40	
$t_{dis}$	G or $\overline{G}$	Y	4.5 V		19	35		53		44	ns
			5.5 V		18	32		48		40	
$t_t$		Y	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance per buffer	No load, $T_A = 25^\circ C$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HCT240 SN54HCT241		SN74HCT240 SN74HCT241		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		20	42		63		53	ns
			5.5 V		19	38		56		48	
$t_{en}$	G or $\overline{G}$	Y	4.5 V		25	52		79		65	ns
			5.5 V		22	47		71		59	
$t_t$		Y	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

Note 1: For load circuit and voltage waveforms, see page 1-14.

3

3  
 HCMOS DEVICES

# CMOS LOGIC DEVICES

Maximum ratings: Exceeding these ratings may damage the device and void the warranty.

See Table 1 for pin connections.

Recommended operating conditions: Exceeding these conditions may affect device performance.

PARAMETER	SYMBOL	UNIT	TYPICAL	MIN.	MAX.
Supply Voltage	V <sub>CC</sub>	V	5.0	4.5	5.5
Input Voltage	V <sub>I</sub>	V	0.1	0.0	1.0
Output Voltage	V <sub>O</sub>	V	0.1	0.0	1.0
Input Current	I <sub>I</sub>	μA	1.0	0.0	1.0
Output Current	I <sub>O</sub>	mA	10.0	0.0	10.0
Propagation Delay	t <sub>pd</sub>	ns	10.0	0.0	10.0
Setup Time	t <sub>su</sub>	ns	10.0	0.0	10.0
Hold Time	t <sub>h</sub>	ns	10.0	0.0	10.0

Notes: 1. All values are at T<sub>A</sub> = 25°C unless otherwise specified.

2. The input current I<sub>I</sub> is measured with the input signal at 0.5V and the output signal at 0.5V.

PARAMETER	SYMBOL	UNIT	TYPICAL	MIN.	MAX.
Supply Voltage	V <sub>CC</sub>	V	5.0	4.5	5.5
Input Voltage	V <sub>I</sub>	V	0.1	0.0	1.0
Output Voltage	V <sub>O</sub>	V	0.1	0.0	1.0
Input Current	I <sub>I</sub>	μA	1.0	0.0	1.0
Output Current	I <sub>O</sub>	mA	10.0	0.0	10.0
Propagation Delay	t <sub>pd</sub>	ns	10.0	0.0	10.0
Setup Time	t <sub>su</sub>	ns	10.0	0.0	10.0
Hold Time	t <sub>h</sub>	ns	10.0	0.0	10.0

Notes: 1. All values are at T<sub>A</sub> = 25°C unless otherwise specified.

3

HCN0000

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC242, SN54HC243 SN74HC242, SN74HC243 QUADRUPLE BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 2-Way Asynchronous Communication Between Data Buses
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These four-data line transceivers are designed for asynchronous two-way communications between data buses. The SN74HC' devices can be used to drive terminated lines down to 133 ohms.

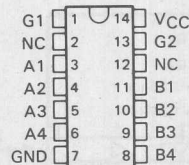
These parts differ from their TTL counterparts (LS, ALS, and AS) in that these CMOS parts do not have a bus-latching mode in which both the outputs are simultaneously enabled. Instead of this latched mode, the buses are isolated, thus preventing potential bus conflicts if both buses are active. However, with the exception of the fourth line of the function table, their functional operation is identical to their TTL counterparts. The two enables have been renamed G1 and G2 since they work together to determine the direction of transmission rather than each enable controlling one direction independently of the other. Whenever G1 and G2 are at opposite logic levels with respect to each other, isolation between buses results.

The SN54HC' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

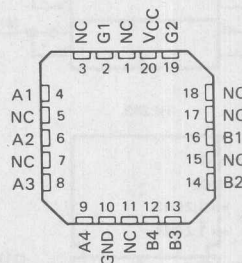
FUNCTION TABLE

INPUTS		'HC242	'HC243
G1	G2		
L	L	$\bar{A}$ to B	A to B
H	H	$\bar{B}$ to A	B to A
H	L	Isolation	Isolation
L	H	Isolation	Isolation

SN54HC242, SN54HC243... J PACKAGE  
SN74HC242, SN74HC243... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC242, SN54HC243... FH OR FK PACKAGE  
(TOP VIEW)



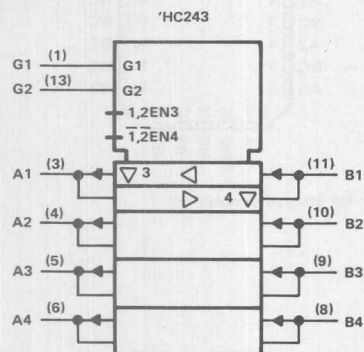
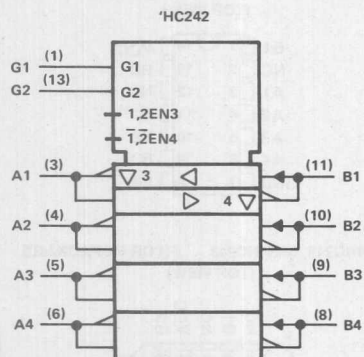
NC—No internal connection

3

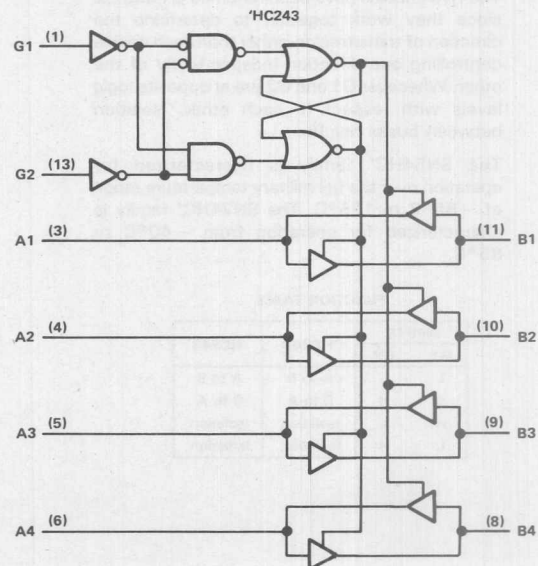
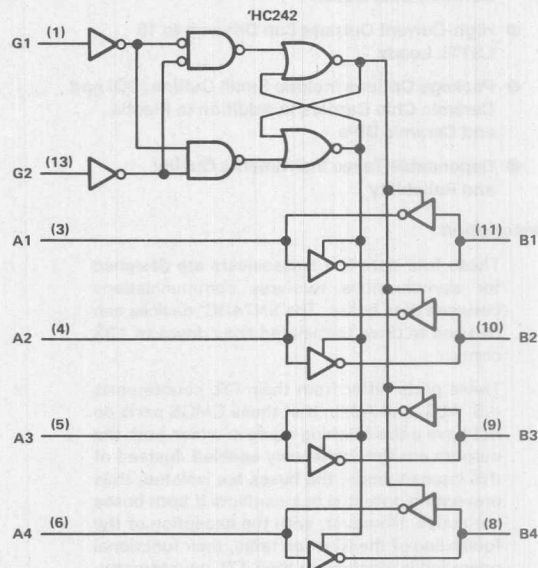
HCMOS DEVICES

**TYPES SN54HC242, SN54HC243  
SN74HC242, SN74HC243  
QUADRUPLE BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

**logic symbol**



**logic diagrams (positive logic)**



Pin numbers shown are for J and N packages.

**3**

**HCMOS DEVICES**

**TYPES SN54HC242, SN54HC243  
SN74HC242, SN74HC243  
QUADRUPLE BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC242 SN54HC243		SN74HC242 SN74HC243		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		45	100		150		125	ns
			4.5 V		12	20		30		25	
			6 V		10	17		26		21	
$t_{en}$	G1 or G2	A or B	2 V		75	150		225		190	ns
			4.5 V		21	30		45		38	
			6 V		17	26		38		32	
$t_{dis}$	G1 or G2	A or B	2 V		48	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		20	26		38		32	
$t_t$		A or B	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	34 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC243 SN54HC243		SN74HC243 SN74HC243		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		63	150		225		190	ns
			4.5 V		17	30		45		38	
			6 V		14	26		38		32	
$t_{en}$	G1 or G2	A or B	2 V		100	200		300		250	ns
			4.5 V		26	40		60		50	
			6 V		21	34		51		43	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**3**  
HCMOS DEVICES

# TYPE 300000 300000 300000 WITH 3-STATE OUTPUT

Maximum ratings: Absolute maximum ratings are shown in parentheses.

See Table 1, page 3-2

Recommended operating conditions: Recommended operating conditions are shown in parentheses.

Parameter	Symbol	Units	Typical	Max	Min
Supply Voltage	$V_{CC}$	V	5.0	5.5	4.5
Input Voltage	$V_{in}$	V	0.0	5.5	0.0
Output Voltage	$V_{out}$	V	0.0	5.5	0.0
Input Current	$I_{in}$	mA	0.0	1.0	0.0
Output Current	$I_{out}$	mA	0.0	1.0	0.0
Power Dissipation	$P_d$	mW	0.0	1.0	0.0
Storage Temperature	$T_{stg}$	°C	-55	125	-55
Operating Temperature	$T_{op}$	°C	-55	125	-55

Note: 1. The maximum power dissipation is limited by the ambient temperature and the mounting conditions.

Note: 2. The maximum power dissipation is limited by the ambient temperature and the mounting conditions.

Parameter	Symbol	Units	Typical	Max	Min
Supply Voltage	$V_{CC}$	V	5.0	5.5	4.5
Input Voltage	$V_{in}$	V	0.0	5.5	0.0
Output Voltage	$V_{out}$	V	0.0	5.5	0.0
Input Current	$I_{in}$	mA	0.0	1.0	0.0
Output Current	$I_{out}$	mA	0.0	1.0	0.0
Power Dissipation	$P_d$	mW	0.0	1.0	0.0
Storage Temperature	$T_{stg}$	°C	-55	125	-55
Operating Temperature	$T_{op}$	°C	-55	125	-55

Note: 1. The maximum power dissipation is limited by the ambient temperature and the mounting conditions.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT242, SN54HCT243 SN74HCT242, SN74HCT243 QUADRUPLE BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- 2-Way Asynchronous Communication Between Data Buses
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These four-data line transceivers are designed for asynchronous two-way communications between data buses. The SN74HCT' devices can be used to drive terminated lines down to 133 ohms.

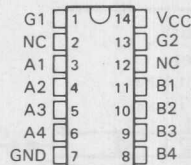
These parts differ from their TTL counterparts (LS, ALS, and AS) in that these CMOS parts do not have a bus-latching mode in which both the outputs are simultaneously enabled. Instead of this latched mode, the buses are isolated, thus preventing potential bus conflicts if both buses are active. However, with the exception of the fourth line of the function table, their functional operation is identical to their TTL counterparts. The two enables have been renamed G1 and G2 since they work together to determine the direction of transmission rather than each enable controlling one direction independently of the other. Whenever G1 and G2 are at opposite logic levels with respect to each other, isolation between buses results.

The SN54HCT' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

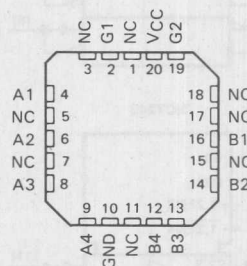
FUNCTION TABLE

INPUTS		'HCT242	'HCT243
G1	G2		
L	L	$\bar{A}$ to B	A to B
H	H	$\bar{B}$ to A	B to A
H	L	Isolation	Isolation
L	H	Isolation	Isolation

SN54HCT242, SN54HCT243 ... J PACKAGE  
SN74HCT242, SN74HCT243 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT242, SN54HCT243 ... FH OR FK PACKAGE  
(TOP VIEW)



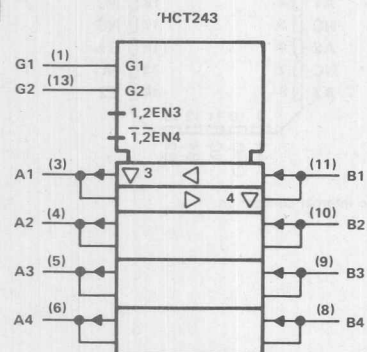
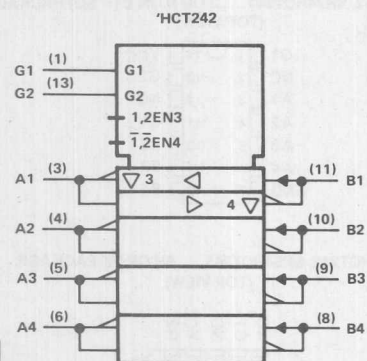
NC—No internal connection

3

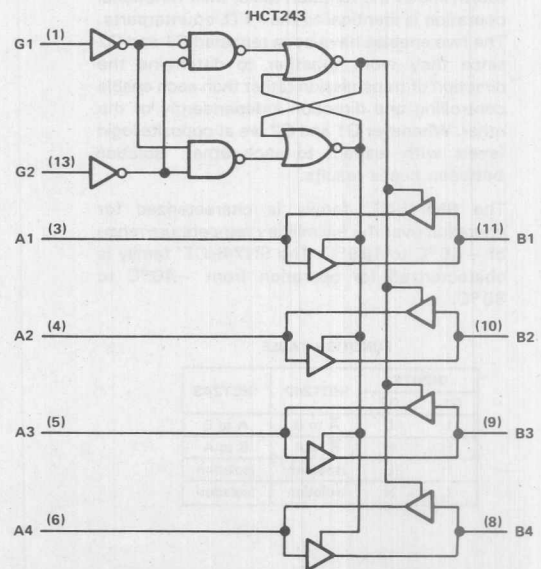
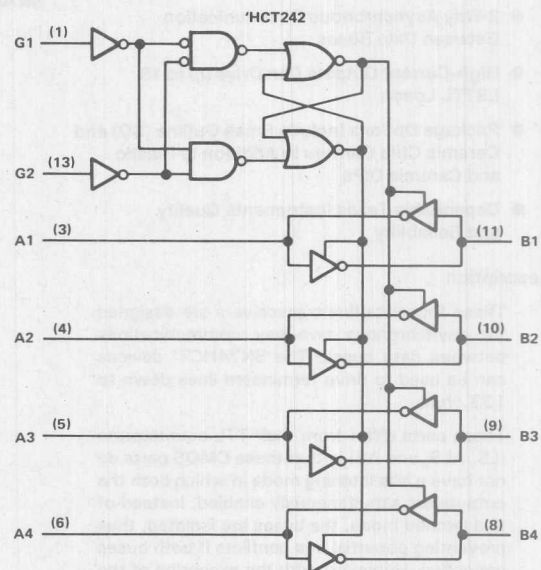
HCMOS DEVICES

**TYPES SN54HCT242, SN54HCT243  
SN74HCT242, SN74HCT243  
QUADRUPLE BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

logic symbol



logic diagrams (positive logic)



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

**TYPES SN54HCT242, SN54HCT243  
SN74HCT242, SN74HCT243  
QUADRUPLER BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT242 SN54HCT243		SN74HCT242 SN74HCT243		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		15	30		45		38	ns
			5.5 V		13	27		41		34	
$t_{en}$	G1 or G2	A or B	4.5 V		21	40		60		50	ns
			5.5 V		19	36		54		45	
$t_{dis}$	G1 or G2	A or B	4.5 V		19	40		60		50	ns
			5.5 V		18	36		54		45	
$t_t$		A or B	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT242 SN54HCT243		SN74HCT242 SN74HCT243		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		21	47		71		59	ns
			5.5 V		18	42		64		53	
$t_{en}$	G1 or G2	A or B	4.5 V		27	57		86		71	ns
			5.5 V		24	51		77		64	
$t_t$		A or B	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

### 3 HCMOS DEVICES

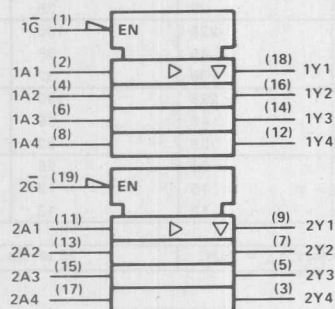
- 3-State Outputs Drive Bus Lines or Buffer Memory Address Registers
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

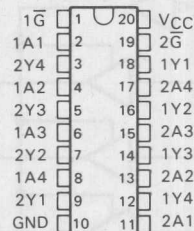
These octal buffers and line drivers are designed specifically to improve both the performance and density of the three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. Taken together with the 'HC240 and 'HC241, these devices provide the choice of selected combinations of inverting outputs, symmetrical  $\bar{G}$  (active-low input control) inputs and complementary  $G$  and  $\bar{G}$  inputs.

The SN54HC244 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC244 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

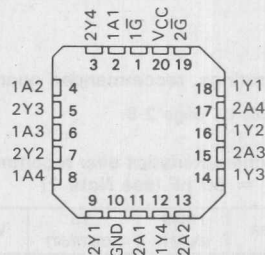
**logic symbol**



**SN54HC244 ... J PACKAGE  
SN74HC244 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC244 ... FH OR FK PACKAGE  
(TOP VIEW)**

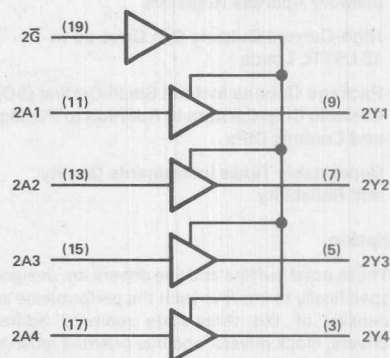
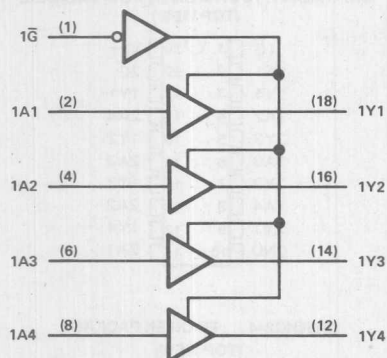


**3**

**HCMOS DEVICES**

# TYPES SN54HC244, SN74HC244 OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

logic diagram (positive logic)



3

HCMOS DEVICES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC244		SN74HC244		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V 4.5 V 6 V		40 13 11	115 23 20		170 34 29		145 29 25	ns
$t_{en}$	$\overline{G}$	Y	2 V 4.5 V 6 V		75 15 13	150 30 26		225 45 38		190 38 32	ns
$t_{dis}$	$\overline{G}$	Y	2 V 4.5 V 6 V		75 15 13	150 30 26		225 45 38		190 38 32	ns
$t_t$		Y	2 V 4.5 V 6 V		28 8 6	60 12 10		90 18 15		75 15 13	<sup>a</sup> ns

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# TYPES SN54HC244, SN74HC244 OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC244			SN74HC244			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{pd}$	A	Y	2 V		56	165			245			210	ns
			4.5 V		18	33			49			42	
			6 V		15	28			42			35	
$t_{en}$	$\overline{G}$	Y	2 V		100	200			300			250	ns
			4.5 V		20	40			60			50	
			6 V		17	34			51			43	
$t_t$		Y	2 V		45	210			315			265	ns
			4.5 V		17	42			63			53	
			6 V		13	36			53			45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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HCMOS DEVICES



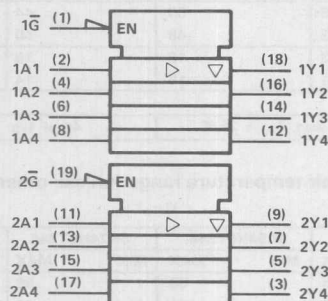
- Inputs are TTL-Voltage Compatible
- 3-State Outputs Drive Bus Lines or Buffer Memory Address Registers
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

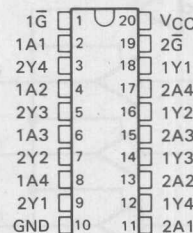
These octal buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. Taken together with the 'HCT240 and 'HCT241, these devices provide the choice of selected combinations of inverting outputs, symmetrical  $\bar{G}$  (active-low input control) inputs, and complementary  $G$  and  $\bar{G}$  inputs.

The SN54HCT244 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT244 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

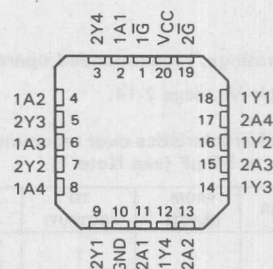
### logic symbol



SN54HCT244... J PACKAGE  
SN74HCT244... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



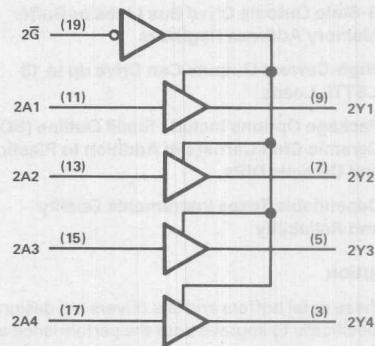
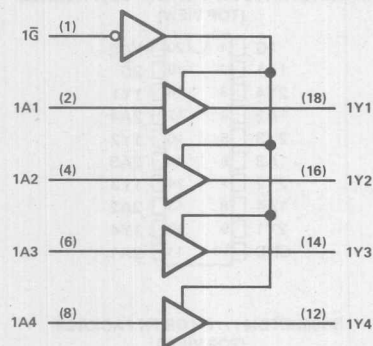
SN54HCT244... FH OR FK PACKAGE  
(TOP VIEW)



3

HCMOS DEVICES

## logic diagram (positive logic)



## maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT244		SN74HCT244		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		15	28		42		35	ns
			5.5 V		13	25		38		32	
$t_{en}$	$\overline{G}$	Y	4.5 V		21	35		53		44	ns
			5.5 V		19	32		48		40	
$t_{dis}$	$\overline{G}$	Y	4.5 V		19	35		53		44	ns
			5.5 V		18	32		48		40	
$t_t$		Y	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance per buffer	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT244		SN74HCT244		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		21	45		68		56	ns
			5.5 V		18	40		61		51	
$t_{en}$	$\overline{G}$	Y	4.5 V		25	52		79		65	ns
			5.5 V		22	47		71		59	
$t_t$		Y	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

- High-Current 3-State Outputs Drive Bus Lines Directly or Up to 15 LSTTL-Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

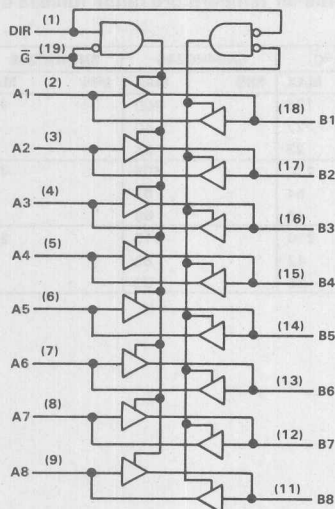
## description

These octal bus transceivers are designed for synchronous two-way communication between data buses. The control function implementation minimizes external timing requirements.

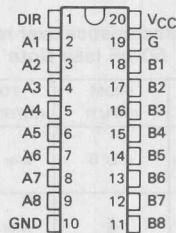
The devices allow data transmission from the A bus to the B bus or from the B bus to the A bus depending upon the logic level at the direction control (DIR) input. The enable input ( $\bar{G}$ ) can be used to disable the device so that the buses are effectively isolated.

The SN54HC245 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC245 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

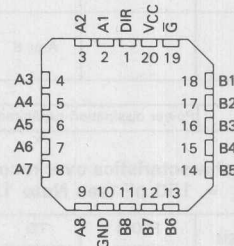
## logic diagram (positive logic)



SN54HC245... J PACKAGE  
SN74HC245... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



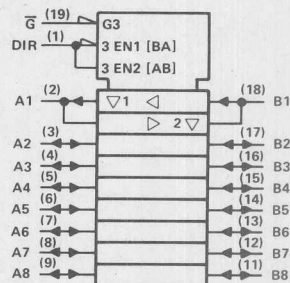
SN54HC245... FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE

CONTROL INPUTS		OPERATION
$\bar{G}$	DIR	
L	L	B data to A bus
L	H	A data to B bus
H	X	Isolation

## logic symbol



# **TYPES SN54HC245, SN74HC245** **OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC245		SN74HC245		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		40	105		160		130	ns
			4.5 V		15	21		32		26	
			6 V		12	18		27		22	
$t_{en}$	$\bar{G}$	A or B	2 V		125	230		340		290	ns
			4.5 V		23	46		68		58	
			6 V		20	39		58		49	
$t_{dis}$	$\bar{G}$	A or B	2 V		74	200		300		250	ns
			4.5 V		25	40		60		50	
			6 V		21	34		51		43	
$t_t$		A or B	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC245		SN74HC245		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		54	135		200		170	ns
			4.5 V		18	27		40		34	
			6 V		15	23		34		29	
$t_{en}$	$\bar{G}$	A or B	2 V		150	270		405		335	ns
			4.5 V		31	54		81		67	
			6 V		25	46		69		56	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



- 3-State Version of 'HC151
- High-Current 3-State Outputs Interface Directly with System Bus or Can Drive up to 15 LSTTL Loads
- Performs Parallel-to-Serial Conversion
- Complementary Outputs Provide True and Inverted Data
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These data selectors/multiplexers contain full binary decoding to select one-of-eight data sources and feature strobe-controlled complementary three-state outputs.

The three-state outputs can interface with and drive data lines of bus-organized systems. With all but one of the common outputs disabled (at a high-impedance state), the low-impedance of the single enabled output will drive the bus line to a high or low logic level. Both outputs are controlled by the strobe ( $\bar{G}$ ). The outputs are disabled when  $\bar{G}$  is high.

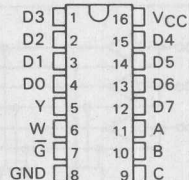
The SN54HC251 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC251 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**FUNCTION TABLE**

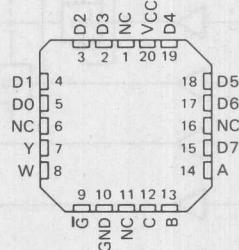
FUNCTION TABLE				OUTPUTS	
INPUTS			STROBE $\overline{G}$		
SELECT				Y	W
C	B	A			
X	X	X	H	Z	Z
L	L	L	L	D0	$\overline{D0}$
L	L	H	L	D1	$\overline{D1}$
L	H	L	L	D2	$\overline{D2}$
L	H	H	L	D3	$\overline{D3}$
H	L	L	L	D4	$\overline{D4}$
H	L	H	L	D5	$\overline{D5}$
H	H	L	L	D6	$\overline{D6}$
H	H	H	L	D7	$\overline{D7}$

D0, D1 . . . D7 = the level of the respective D input

**SN54HC251 . . . J PACKAGE  
SN74HC251 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**

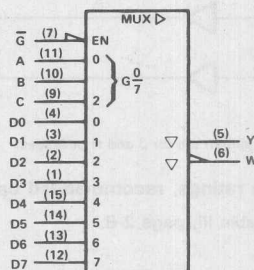


**SN54HC251 . . . FH OR FK PACKAGE  
(TOP VIEW)**



NC—No internal connection

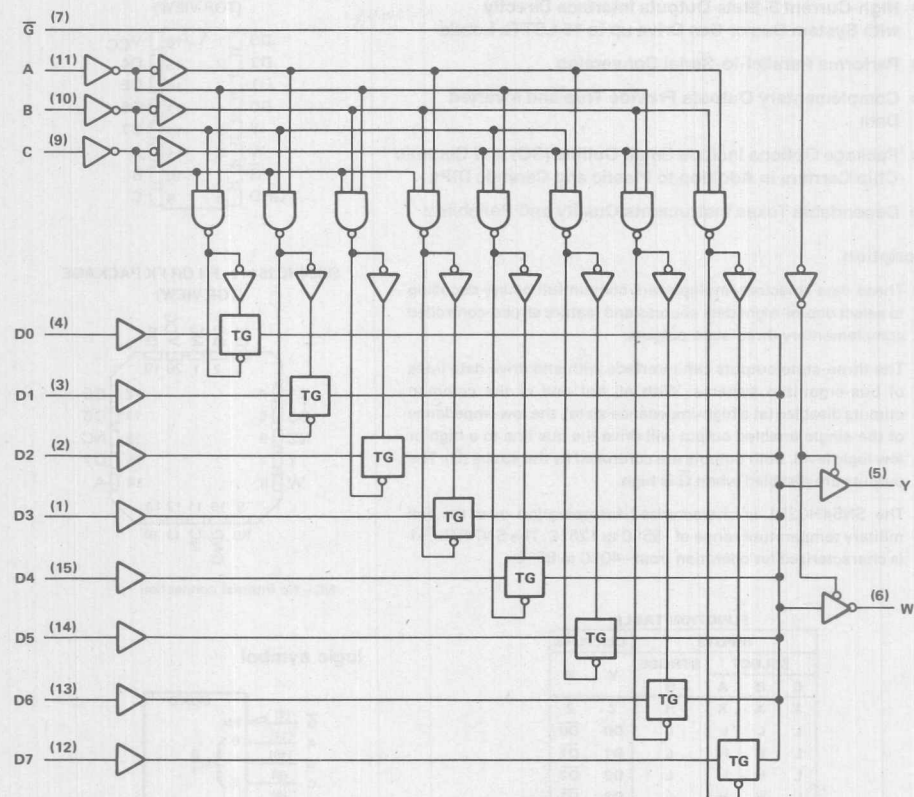
### logic symbol



\*Pin numbers shown are for J and N package.

# **TYPES SN54HC251, SN74HC251** **DATA SELECTORS/MULTIPLEXERS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

3

HC MOS DEVICES

# **TYPES SN54HC251, SN74HC251** **DATA SELECTORS/MULTIPLEXERS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC251		SN74HC251		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	W or Y	2 V		58	205		300		256	ns
			4.5 V		21	41		60		51	
			6 V		19	35		51		44	
$t_{pd}$	Any D	W or Y	2 V		44	195		283		244	ns
			4.5 V		17	39		57		49	
			6 V		15	33		48		41	
$t_{en}$	$\overline{G}$	W or Y	2 V		30	145		210		181	ns
			4.5 V		10	29		42		36	
			6 V		9	25		36		31	
$t_{dis}$	$\overline{G}$	W or Y	2 V		25	195		283		244	ns
			4.5 V		15	39		57		49	
			6 V		14	33		48		41	
$t_t$			2 V		20	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	70 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC251		SN74HC251		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A, B, or C	W or Y	2 V		72	300		450		375	ns
			4.5 V		25	60		90		75	
			6 V		22	52		77		65	
$t_{pd}$	Any D	W or Y	2 V		59	300		450		375	ns
			4.5 V		21	60		90		75	
			6 V		18	52		77		65	
$t_{en}$	$\overline{G}$	W or Y	2 V		50	230		340		335	ns
			4.5 V		17	46		68		57	
			6 V		15	40		58		50	
$t_t$			2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC253, SN74HC253 DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 3-State Versions of 'HC153
- High-Current Outputs Drive up to 15 LSTTL Loads
- Permits Multiplexing from N Lines to 1 Line
- Performs Parallel-to-Serial Conversion
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

Each of these data selectors/multiplexers contains inverters and drivers to supply full binary decoding data selection to the AND-OR gates. Separate output control inputs are provided for each of the two four-line sections.

The three-state outputs can interface with and drive data lines of bus-organized systems. With all but one of the common outputs disabled (at a high-impedance state) the low-impedance of the single enabled output will drive the bus line to a high or low logic level. Each output has its own strobe ( $\overline{G}$ ). The output is disabled when its strobe is high.

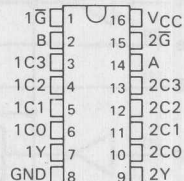
The SN54HC253 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC253 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

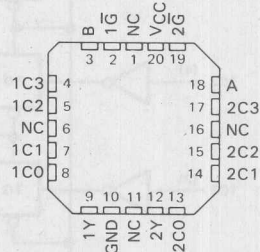
SELECT INPUTS		DATA INPUTS				OUTPUT CONTROL	OUTPUT
B	A	C0	C1	C2	C3	$\overline{G}$	Y
X	X	X	X	X	X	H	Z
L	L	L	X	X	X	L	L
L	L	H	X	X	X	L	H
L	H	X	L	X	X	L	L
L	H	X	H	X	X	L	H
H	L	X	X	L	X	L	L
H	L	X	X	H	X	L	H
H	H	X	X	X	L	L	L
H	H	X	X	X	H	L	H

Address inputs A and B are common to both sections.

SN54HC253 ... J PACKAGE  
SN74HC253 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

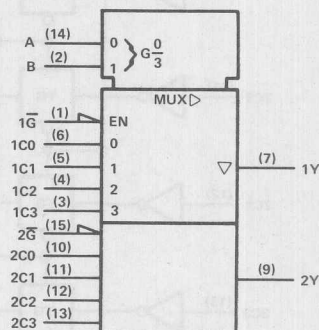


SN54HC253 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



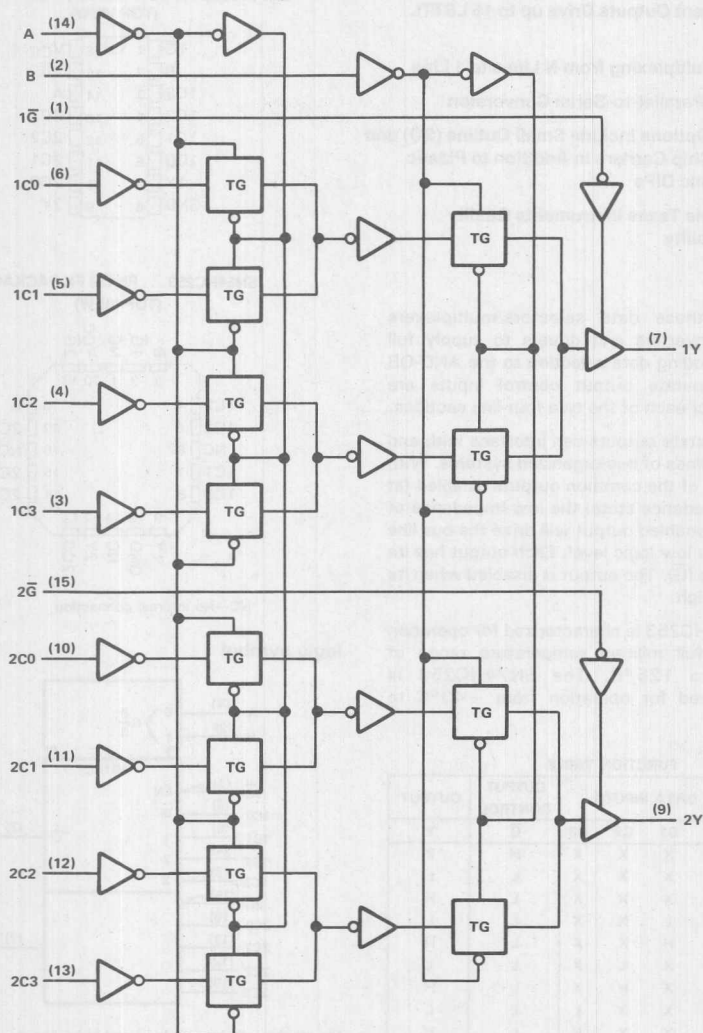
Pin numbers shown are for J and N packages

3

HCMOS DEVICES

**TYPES SN54HC253, SN74HC253**  
**DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**  
**WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

**3**

**HCMOS DEVICES**



**TYPES SN54HC253, SN74HC253**  
**DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**  
**WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC253		SN74HC253		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Any Y	2 V		62	150		225		190	ns
			4.5 V		19	30		45		38	
			6 V		16	26		38		32	
$t_{pd}$	Data (Any C)	Y	2 V		54	126		210		175	ns
			4.5 V		16	28		42		35	
			6 V		13	23		36		30	
$t_{en}$	$\overline{G}$	Y	2 V		28	100		150		125	ns
			4.5 V		11	20		30		25	
			6 V		9	17		26		21	
$t_{dis}$	$\overline{G}$	Y	2 V		21	135		203		170	ns
			4.5 V		14	30		45		38	
			6 V		12	25		38		31	
$t_t$		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per multiplexer	No load, $T_A = 25^\circ\text{C}$	45 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC253		SN74HC253		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Any Y	2 V		76	235		355		295	ns
			4.5 V		23	47		71		59	
			6 V		20	41		60		51	
$t_{pd}$	Data (Any C)	Y	2 V		68	220		335		275	ns
			4.5 V		20	44		67		55	
			6 V		17	38		57		51	
$t_{en}$	$\overline{G}$	Y	2 V		44	185		280		230	ns
			4.5 V		16	37		56		46	
			6 V		14	32		48		40	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## 3

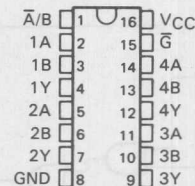
# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC257, SN54HC258, SN74HC257, SN74HC258 QUAD 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- High-Current 3-State Outputs Interface Directly with System Bus or Can Drive up to 15 LSTTL Loads
- Provides Bus Interface from Multiple Sources in High Performance Systems
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC257, SN54HC258 . . . J PACKAGE  
SN74HC257, SN74HC258 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



### description

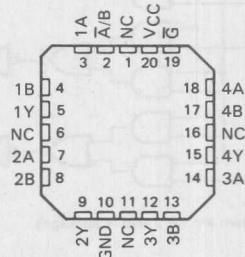
These devices are designed to multiplex signals from four-bit data sources to four-output data lines in bus-organized systems. The 3-state outputs will not load the data lines when the output control pin ( $\bar{G}$ ) is at a high-logic level.

The SN54HC257 and SN54HC258 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC257 and SN74HC258 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

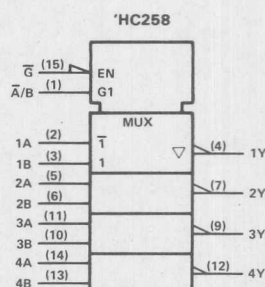
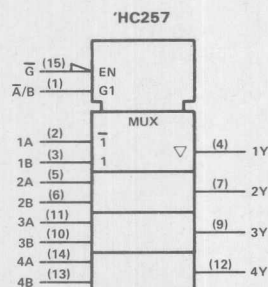
OUTPUT CONTROL $\bar{G}$	INPUTS		DATA		OUTPUT Y	
	SELECT $\bar{A}/\bar{B}$		A	B	'HC257	'HC258
H	X	X	X	X	Z	Z
L	L	L	X	X	L	H
L	L	H	X	X	H	L
L	H	X	L	L	L	H
L	H	X	H	H	L	L

SN54HC257, SN54HC258 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbols



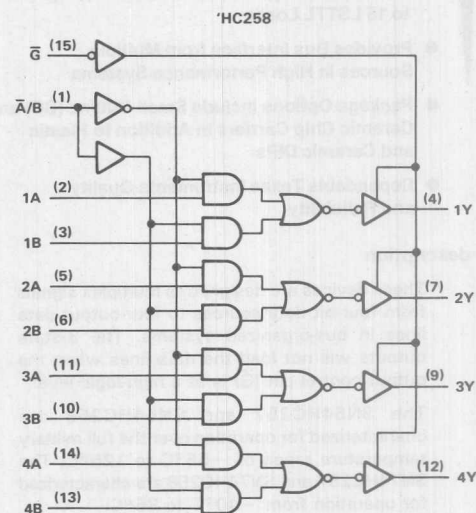
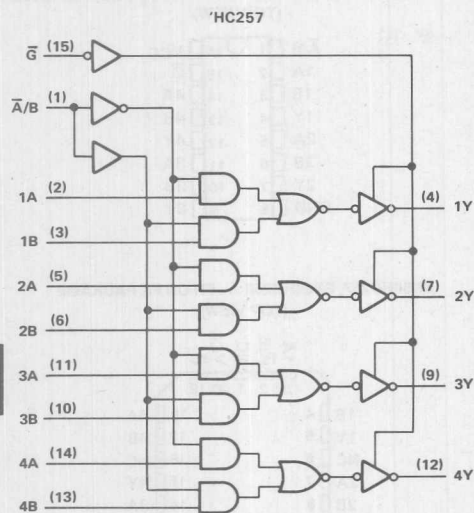
Pin numbers shown are for J and N packages.

TEXAS  
INSTRUMENTS

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**TYPES SN54HC257, SN54HC258, SN74HC257, SN74HC258**  
**QUAD 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**  
**WITH 3-STATE OUTPUTS**

logic diagrams (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

3  
**HC MOS DEVICES**

**TYPES SN54HC257, SN74HC257**  
**QUAD 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**  
**WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC257		SN74HC257		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Any Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		9	17		25		21	
$t_{pd}$	$\bar{A}/B$	Any Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		9	17		25		21	
$t_{en}$	$\bar{G}$	Any Y	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{dis}$	$\bar{G}$	Any Y	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per multiplexer	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC257		SN74HC257		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Any Y	2 V		75	150		245		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{pd}$	$\bar{A}/B$	Any Y	2 V		75	150		245		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{en}$	$\bar{G}$	Any Y	2 V		100	200		250		300	ns
			4.5 V		24	40		60		50	
			6 V		18	34		51		43	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

**3**  
**HCMOS DEVICES**

TYPES SN54HC258, SN74HC258  
QUAD 2-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS  
WITH 3-STATE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC258		SN74HC258		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Any Y	2 V		60	100		150		125	ns
			4.5 V		13	20		30		25	
			6 V		12	17		25		21	
t <sub>pd</sub>	$\bar{A}/B$	Any Y	2 V		60	115		175		145	ns
			4.5 V		13	23		35		29	
			6 V		12	20		30		25	
t <sub>en</sub>	$\bar{G}$	Any Y	2 V		70	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>dis</sub>	$\bar{G}$	Any Y	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per multiplexer	No load, T <sub>A</sub> = 25°C	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC258		SN74HC258		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Any Y	2 V		95	150		245		190	ns
			4.5 V		23	30		45		38	
			6 V		21	26		38		32	
t <sub>pd</sub>	$\bar{A}/B$	Any Y	2 V		95	165		240		210	ns
			4.5 V		23	33		48		42	
			6 V		21	28		41		36	
t <sub>en</sub>	$\bar{G}$	Any Y	2 V		100	200		300		250	ns
			4.5 V		24	40		60		50	
			6 V		18	34		51		43	
t <sub>t</sub>		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.



- 8-Bit Parallel-Out Storage Register Performs Serial-to-Parallel Conversion with Storage
- Asynchronous Parallel Clear
- Active-High Decoder
- Enable Input Simplifies Expansion
- Expandable for N-Bit Applications
- Four Distinct Functional Modes
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

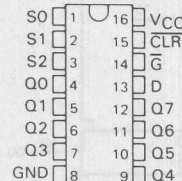
## description

These 8-bit addressable latches are designed for general purpose storage applications in digital systems. Specific uses include working registers, serial-holding registers, and active-high decoders or demultiplexers. They are multifunctional devices capable of storing single-line data in eight addressable latches, and being a 1-of-8 decoder or demultiplexer with active-high outputs.

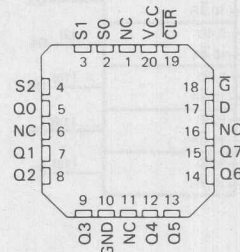
Four distinct modes of operation are selectable by controlling the clear ( $\overline{\text{CLR}}$ ) and enable ( $\overline{\text{G}}$ ) inputs as enumerated in the function table. In the addressable-latch mode, data at the data-in terminal is written into the addressed latch. The addressed latch will follow the data input with all unaddressed latches remaining in their previous states. In the memory mode, all latches remain in their previous states and are unaffected by the data or address inputs. To eliminate the possibility of entering erroneous data in the latches, enable  $\overline{\text{G}}$  should be held high (inactive) while the address lines are changing. In the 1-of-8 decoding or demultiplexing mode, the addressed output will follow the level of the D input with all other outputs low. In the clear mode, all outputs are low and unaffected by the address and data inputs.

The SN54HC259 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC259 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC259 ... J PACKAGE  
SN74HC259 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC259 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE

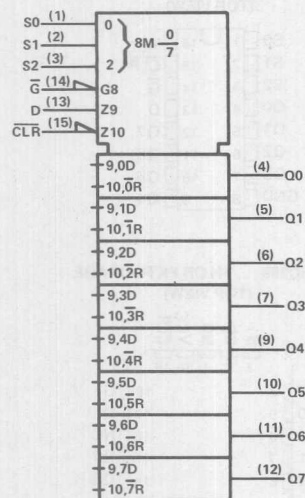
INPUTS		OUTPUT OF ADDRESSED LATCH	EACH OTHER OUTPUT	FUNCTION
$\overline{\text{CLR}}$	$\overline{\text{G}}$			
H	L	D	$Q_iO$	Addressable Latch
H	H	$Q_iO$	$Q_iO$	Memory
L	L	D	L	8-Line Demultiplexer
L	H	L	L	Clear

LATCH SELECTION TABLE

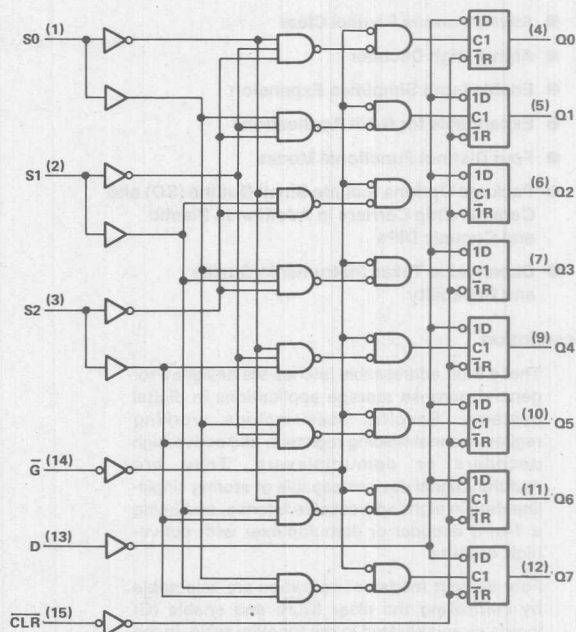
SELECT INPUTS			LATCH ADDRESSED
S2	S1	S0	
L	L	L	0
L	L	H	1
L	H	L	2
L	H	H	3
H	L	L	4
H	L	H	5
H	H	L	6
H	H	H	7

# **TYPES SN54HC259, SN74HC259** **8-BIT ADDRESSABLE LATCHES**

logic symbol

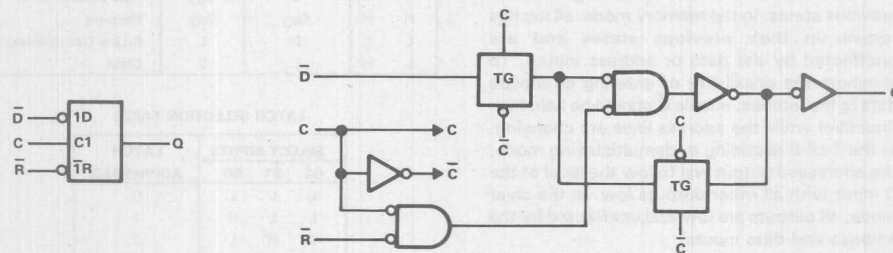


logic diagram (positive logic)



Pin numbers shown are for J and N packages.

logic symbol and logic diagram, each internal latch (positive logic)



3

HCMOS DEVICES

# TYPES SN54HC259, SN74HC259 8-BIT ADDRESSABLE LATCHES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC259		SN74HC259		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub>	Pulse duration	$\overline{\text{CLR}}$ low	2 V	80	120		100		ns
			4.5 V	16	24		20		
			6 V	14	20		17		
	$\overline{\text{G}}$ low		2 V	80	120		100		
			4.5 V	16	24		20		
			6 V	14	20		17		
t <sub>su</sub>	Setup time, data or address before $\overline{\text{G}}$ ↑	2 V	75		115		95		ns
		4.5 V	15		23		19		
		6 V	13		20		16		
t <sub>h</sub>	Hold time, data or address after $\overline{\text{G}}$ ↑	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC259		SN74HC259		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>PHL</sub>	$\overline{\text{CLR}}$	Any Q	2 V		60	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		14	26		38		32	
t <sub>pd</sub>	Data	Any Q	2 V		56	130		195		165	ns
			4.5 V		17	26		39		33	
			6 V		13	22		33		28	
t <sub>pd</sub>	Address	Any Q	2 V		74	200		300		250	ns
			4.5 V		21	40		60		50	
			6 V		17	34		51		43	
t <sub>pd</sub>	$\overline{\text{G}}$	Any Q	2 V		66	170		255		215	ns
			4.5 V		20	34		51		43	
			6 V		16	29		43		37	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25 °C	33 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC266, SN74HC266 QUADRUPL 2-INPUT EXCLUSIVE-NOR GATES WITH OPEN-DRAIN OUTPUTS**

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

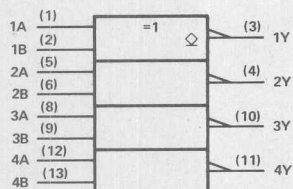
- Dependable Texas Instruments Quality and Reliability

### **description**

These devices are composed of four independent 2-input exclusive-NOR gates and feature open-drain outputs. They perform the Boolean functions:  $Y = A \oplus B = \overline{A}B + AB$  in positive logic.

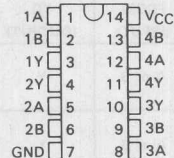
The SN54HC266 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC266 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### **logic symbol**

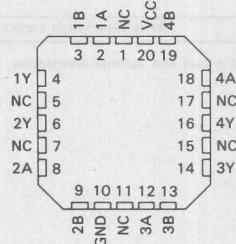


Pin numbers shown are for J and N packages.

SN54HC266 ... J PACKAGE  
SN74HC266 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC266 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

**FUNCTION TABLE**

INPUTS		OUTPUT Y
A	B	
L	L	H
L	H	L
H	L	L
H	H	H

### **maximum ratings, recommended operating conditions, and electrical characteristics**

See Table I, page 2-4.

3

HC MOS DEVICES

**TYPES SN54HC266, SN74HC266**  
**QUADRUPLE 2-INPUT EXCLUSIVE-NOR GATES WITH OPEN-DRAIN OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC266		SN74HC266		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>PLH</sub>	A or B	Y	2 V		60	125		190		155	ns
			4.5 V		13	25		38		31	
			6 V		10	23		32		26	
t <sub>PHL</sub>	A or B	Y	2 V		60	100		150		125	ns
			4.5 V		13	20		30		25	
			6 V		10	17		25		21	
t <sub>f</sub>		Y	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C			35 pF typ		

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC273, SN74HC273 OCTAL D-TYPE FLIP-FLOPS WITH CLEAR

D2684, DECEMBER 1982—REVISED MARCH 1984

- Contains Eight Flip-Flops with Single-Rail Outputs
- Direct Clear Input
- Individual Data Input to Each Flip-Flop
- Applications Include:  
Buffer/Storage Registers  
Shift Registers  
Pattern Generators
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These circuits are positive-edge-triggered D-type flip-flops with a direct clear input.

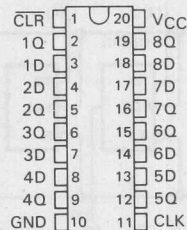
Information at the D inputs meeting the setup time requirements is transferred to the Q outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a particular voltage level and is not directly related to the transition time of the positive-going pulse. When the clock input is at either the high or low level, the D input signal has no effect at the output.

The SN54HC273 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC273 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

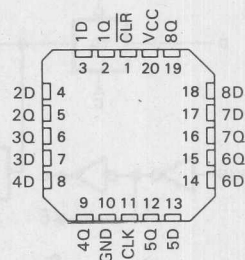
FUNCTION TABLE  
(EACH FLIP-FLOPS)

INPUTS			OUTPUT
CLEAR	CLOCK	D	Q
L	X	X	L
H	↑	H	H
H	↑	L	L
H	L	X	$Q_0$

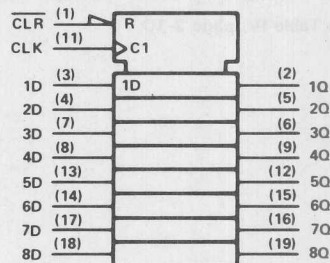
SN54HC273 ... J PACKAGE  
SN74HC273 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC273 ... FH OR FK PACKAGE  
(TOP VIEW)



## logic symbol

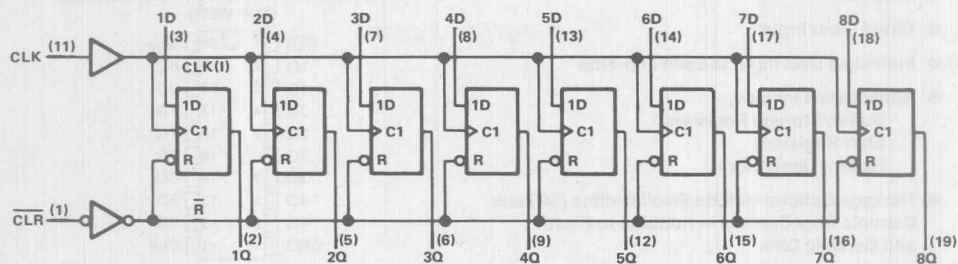


3

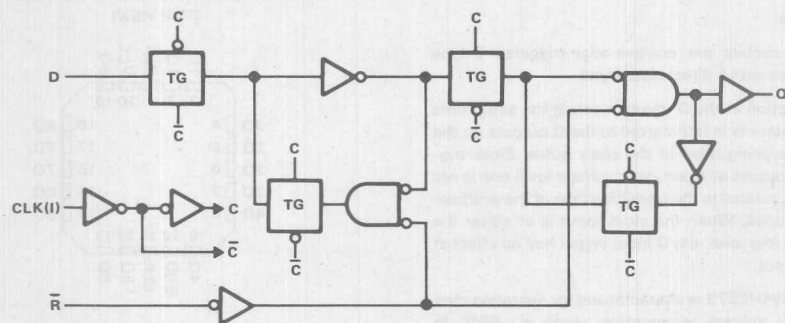
HCMOS DEVICES

# **TYPES SN54HC273, SN74HC273** **OCTAL D-TYPE FLIP-FLOPS WITH CLEAR**

logic diagram, total device (positive logic)



logic diagram each flip-flop (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

3

HCMOS DEVICES

# TYPES SN54HC273, SN74HC273 OCTAL D-TYPE FLIP-FLOPS WITH CLEAR

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC273		SN74HC273		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		5	0	4	0	4	MHz
		4.5 V	0		27	0	18	0	21	
		6 V	0		32	0	21	0	25	
t <sub>w</sub>	Pulse duration	2 V	80			120		100		ns
		4.5 V	16			24		20		
		6 V	14			20		17		
	CLK high or low	2 V	80			120		100		ns
		4.5 V	16			24		20		
		6 V	14			20		17		
t <sub>su</sub>	Setup time before CLK †	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			25		21		
	CLR inactive	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			25		21		
t <sub>h</sub>	Hold time, data after CLK †	2 V	0			0		0		ns
		4.5 V	0			0		0		
		6 V	0			0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC273		SN74HC273		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	11		4		4		MHz
			4.5 V	27	50		18		21		
			6 V	32	60		28		25		
t <sub>PHL</sub>	CLR	Any	2 V		55	160		240		200	ns
			4.5 V		15	32		48		40	
			6 V		12	27		41		34	
t <sub>pd</sub>	CLK	Any	2 V		56	160		240		200	ns
			4.5 V		15	32		48		40	
			6 V		13	27		41		34	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25 °C	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC280, SN74HC280 9-BIT ODD/EVEN PARITY GENERATORS/CHECKERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Generates Either Odd or Even Parity for Nine Data Lines
- Cascadable for n-Bits
- Can Be Used to Upgrade Existing Systems Using MSI Parity Circuits
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

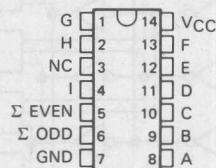
These universal, monolithic, nine-bit parity generators/checkers feature odd and even outputs to facilitate operation of either odd or even parity application. The word-length capability is easily expanded by cascading.

The SN54HC280 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC280 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

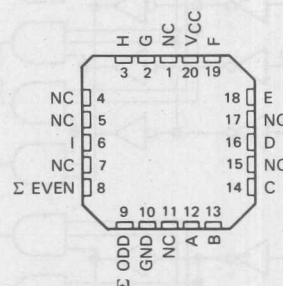
FUNCTION TABLE

NUMBER OF INPUTS A THRU I THAT ARE HIGH	OUTPUTS	
	$\Sigma$ EVEN	$\Sigma$ ODD
0, 2, 4, 6, 8	H	L
1, 3, 5, 7, 9	L	H

SN54HC280 . . . J PACKAGE  
SN74HC280 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

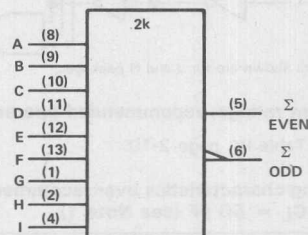


SN54HC280 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol

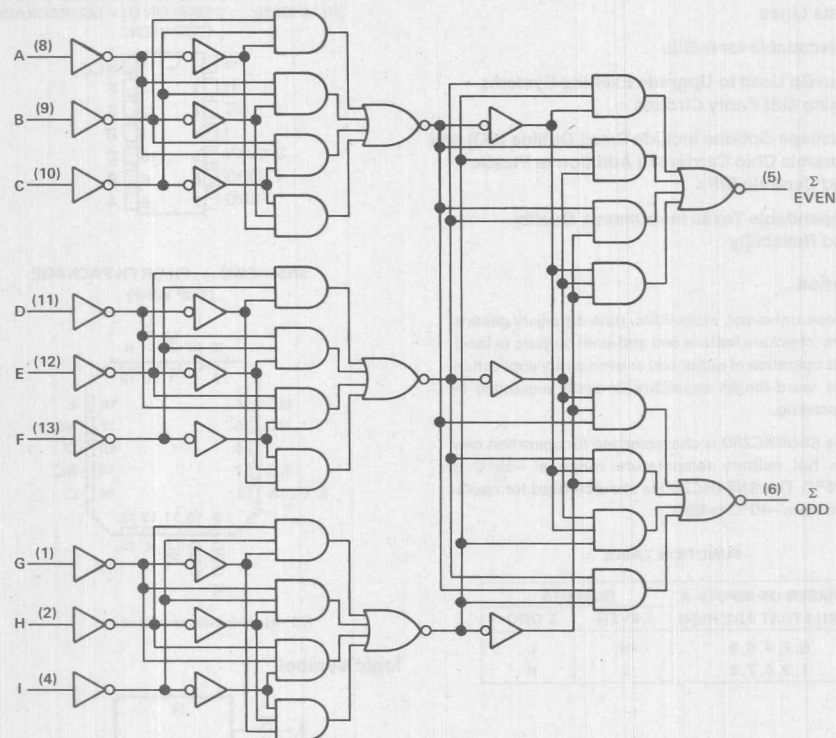


Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

#### maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC280		SN74HC280		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A thru I	Σ Even	2 V		103	205		305		260	ns
		or	4.5 V		21	41		61		52	
		Σ Odd	6 V		17	35		52		44	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance			No load, T <sub>A</sub> = 25°C					60 pF typ		

NOTE 1: For load circuits and voltage waveforms, see page 1-14.



- Selects One of Two 4-Bit Data Sources and Stores Data Synchronously with System Clock
- Dual Source for Operands and Constants in Arithmetic Processor; Can Release Processor Register Files for Acquiring New Data
- Implements Separate Registers Capable of Parallel Exchange of Contents, yet Retains External Loads Capability
- Has Universal-Type Register for Implementing Various Shift Patterns
- Has Compound Left-Right Capability
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

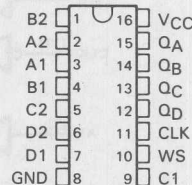
**description**

This quadruple two-input multiplexer with storage provides essentially the equivalent functional capabilities of two separate MSI functions ('HC157 and 'HC175) in a single 16-pin package.

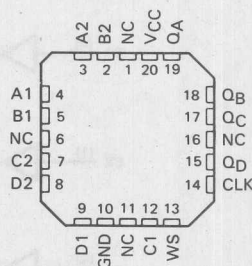
When the Word-Select (WS) input is low, word one (A1, B1, C1, D1) is applied to the flip-flops. A high Word-Select input causes word two (A2, B2, C2, D2) to be selected. The selected word is clocked to the output terminals on the negative-going edge of the clock pulse.

The SN54HC298 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC298 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC298 . . . J PACKAGE  
SN74HC298 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

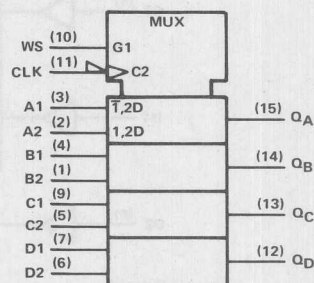


SN54HC298 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

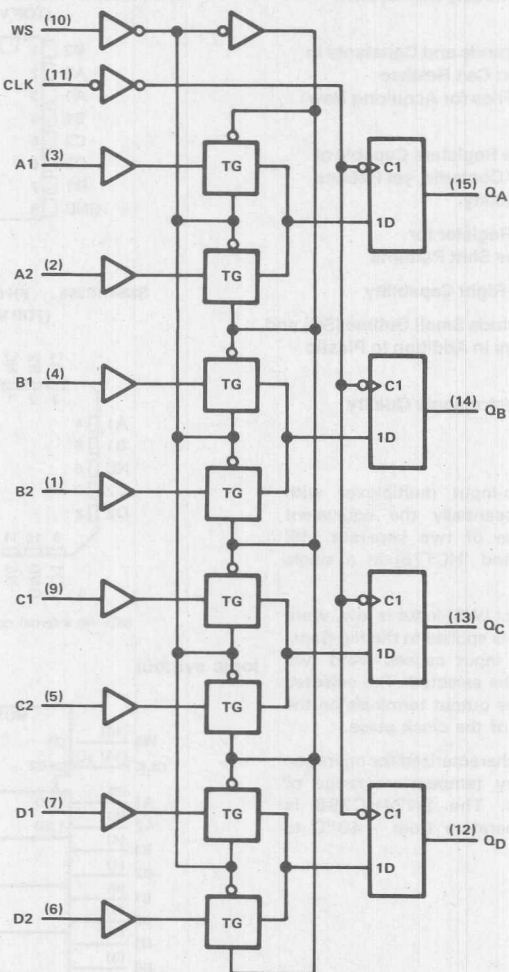
**logic symbol**



Pin numbers shown are for J and N packages.

**TYPES SN54HC298, SN74HC298**  
**QUADRUPLE 2-INPUT MULTIPLEXER WITH STORAGE**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**absolute maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

# **TYPES SN54HC298, SN74HC298** **QUADRUPLE 2-INPUT MULTIPLEXER WITH STORAGE**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC298		SN74HC298		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V			6.5		4.3		5.5	MHz
		4.5 V			33		22		27	
		6 V			38		25		31	
t <sub>w</sub>	Pulse duration, CLK high or low	2 V		75		115		95		ns
		4.5 V		15		23		19		
		6 V		13		20		16		
t <sub>su</sub>	Data before CLK ↓	2 V		80		125		105		ns
		4.5 V		16		25		21		
		6 V		14		21		18		
	WS before CLK ↓	2 V		80		125		105		
		4.5 V		16		25		21		
		6 V		14		21		18		
t <sub>h</sub>	Data after CLK ↓	2 V		0		0		0		ns
		4.5 V		0		0		0		
		6 V		0		0		0		
	WS after CLK ↓	2 V		0		0		0		
		4.5 V		0		0		0		
		6 V		0		0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC298		SN74HC298		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V			6.5		4.3		5.5	MHz
			4.5 V			33		22		27	
			6 V			38		25		31	
t <sub>pd</sub>	CLK	Any	2 V		46	125		190		155	ns
			4.5 V		15	25		38		31	
			6 V		12	21		32		26	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per multiplexer	No load, T <sub>A</sub> = 25°C	33 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
**3**  
**HC MOS DEVICES**

# QUADRALE 2-INPUT MULTIPLEX WITH STORAGE

These recommended operating conditions are for the device in the active mode.

Symbol	Parameter	V <sub>CC</sub> = 5V		V <sub>CC</sub> = 10V		Unit
		Min	Max	Min	Max	
I <sub>DD</sub>	Supply current	10	20	10	20	μA
	Supply current with storage	10	20	10	20	μA
I <sub>OL</sub>	Output current	10	20	10	20	μA
	Output current with storage	10	20	10	20	μA
I <sub>OH</sub>	Output current	10	20	10	20	μA
	Output current with storage	10	20	10	20	μA
I <sub>IL</sub>	Input current	10	20	10	20	μA
	Input current with storage	10	20	10	20	μA
I <sub>IH</sub>	Input current	10	20	10	20	μA
	Input current with storage	10	20	10	20	μA
I <sub>OS</sub>	Output short-circuit current	10	20	10	20	μA
	Output short-circuit current with storage	10	20	10	20	μA
I <sub>IS</sub>	Input short-circuit current	10	20	10	20	μA
	Input short-circuit current with storage	10	20	10	20	μA

These recommended operating conditions are for the device in the active mode.

Symbol	Parameter	V <sub>CC</sub> = 5V		V <sub>CC</sub> = 10V		Unit
		Min	Max	Min	Max	
I <sub>DD</sub>	Supply current	10	20	10	20	μA
	Supply current with storage	10	20	10	20	μA
I <sub>OL</sub>	Output current	10	20	10	20	μA
	Output current with storage	10	20	10	20	μA
I <sub>OH</sub>	Output current	10	20	10	20	μA
	Output current with storage	10	20	10	20	μA
I <sub>IL</sub>	Input current	10	20	10	20	μA
	Input current with storage	10	20	10	20	μA
I <sub>IH</sub>	Input current	10	20	10	20	μA
	Input current with storage	10	20	10	20	μA
I <sub>OS</sub>	Output short-circuit current	10	20	10	20	μA
	Output short-circuit current with storage	10	20	10	20	μA
I <sub>IS</sub>	Input short-circuit current	10	20	10	20	μA
	Input short-circuit current with storage	10	20	10	20	μA

These recommended operating conditions are for the device in the active mode.

## 3 HCMOS DEVICES

- Inverting Versions of 'HC153
- High-Current Inverting Outputs Can Drive up to 15 LSTTL Loads
- Permits Multiplexing from n Lines to 1 Line
- Performs Parallel-to-Serial Conversion
- Strobe (Enable) Line Provided for Cascading (N Lines to n Lines)
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

Separate output enable inputs ( $\bar{G}$ ) are provided for each of the two four-line sections of these data selectors/multiplexers.

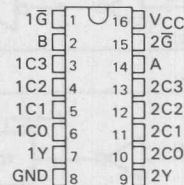
The SN54HC352 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC352 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**FUNCTION TABLE**

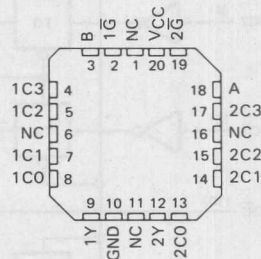
SELECT INPUTS		DATA INPUTS				OUTPUT ENABLE	OUTPUT
B	A	C0	C1	C2	C3	$\bar{G}$	Y
X	X	X	X	X	X	H	H
L	L	L	X	X	X	L	H
L	L	H	X	X	X	L	L
L	H	X	L	X	X	L	H
L	H	X	H	X	X	L	L
H	L	X	X	L	X	L	H
H	L	X	X	H	X	L	L
H	H	X	X	X	L	L	H
H	H	X	X	X	H	L	L

Select inputs A and B are common to both sections.

**SN54HC352 ... J PACKAGE  
SN74HC352 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**

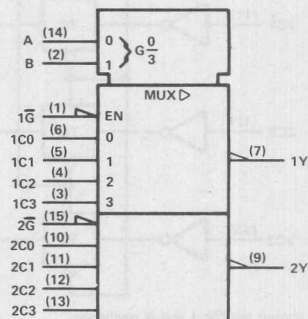


**SN54HC352 ... FH OR FK PACKAGE  
(TOP VIEW)**



NC—No internal connection

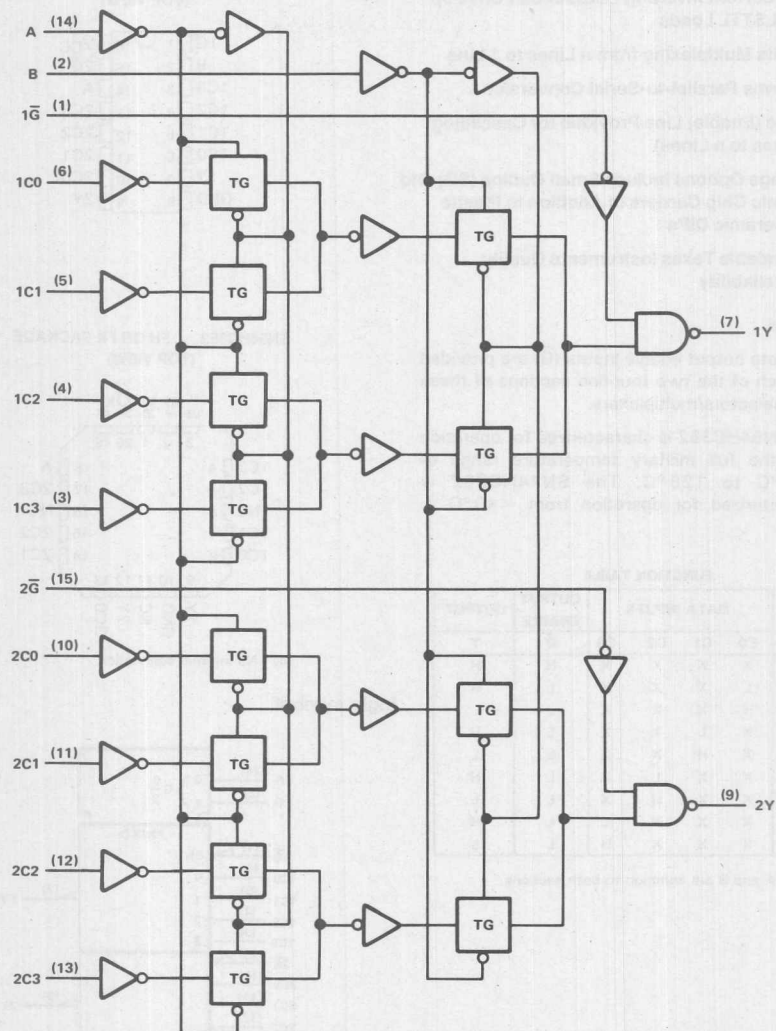
**logic symbol**



Pin numbers shown are for J and N packages.

**TYPES SN54HC352, SN74HC352**  
**DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.



# **TYPES SN54HC352, SN74HC352** **DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC352		SN74HC352		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		58	185		280		230	ns
			4.5 V		17	37		56		46	
			6 V		14	32		48		39	
$t_{pd}$	Data (Any C)	Y	2 V		47	175		265		220	ns
			4.5 V		14	35		53		44	
			6 V		12	30		45		37	
$t_{pd}$	$\overline{G}$	Y	2 V		27	135		205		170	ns
			4.5 V		10	27		41		34	
			6 V		8	23		35		29	
$t_t$		Y	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per data selector	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC352		SN74HC352		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		72	270		410		335	ns
			4.5 V		22	54		82		67	
			6 V		19	47		70		58	
$t_{pd}$	Data (Any C)	Y	2 V		62	260		395		325	ns
			4.5 V		19	52		79		63	
			6 V		16	45		67		56	
$t_{pd}$	$\overline{G}$	Y	2 V		43	220		335		275	ns
			4.5 V		14	44		67		55	
			6 V		12	38		57		48	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC353, SN74HC353 DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Inverting Versions of 'HC253
- Permits Multiplexing from N Lines to 1 Line
- Performs Parallel-to-Serial Conversion
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

Separate output enable inputs ( $\overline{G}$ ) are provided for each of the two four-line sections of these data selectors/multiplexers.

The three-state outputs can interface with and drive data lines of bus-organized systems. With all but one of the common outputs disabled (at a high-impedance state), the low-impedance of the single enable output will drive the bus line to a high or low logic level. Each output has its own output enable ( $\overline{G}$ ). The output is disabled when its output enable is high.

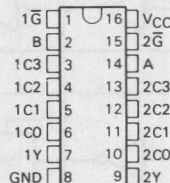
The SN54HC353 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC353 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

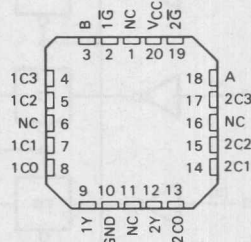
SELECT INPUTS		DATA INPUTS				OUTPUT ENABLE	OUTPUT
B	A	C0	C1	C2	C3	$\overline{G}$	Y
X	X	X	X	X	X	H	Z
L	L	L	X	X	X	L	H
L	L	H	X	X	X	L	L
L	H	X	L	X	X	L	H
L	H	X	H	X	X	L	L
H	L	X	X	L	X	L	H
H	L	X	X	H	X	L	L
H	H	X	X	X	L	L	H
H	H	X	X	X	H	L	L

Select inputs A and B are common to both sections.

SN54HC353... J PACKAGE  
SN74HC353... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

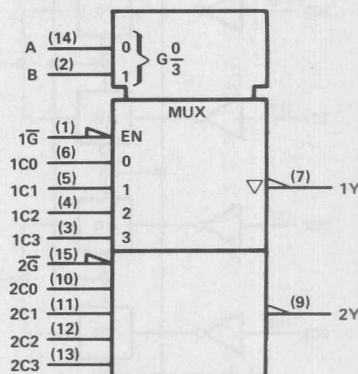


SN54HC353... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



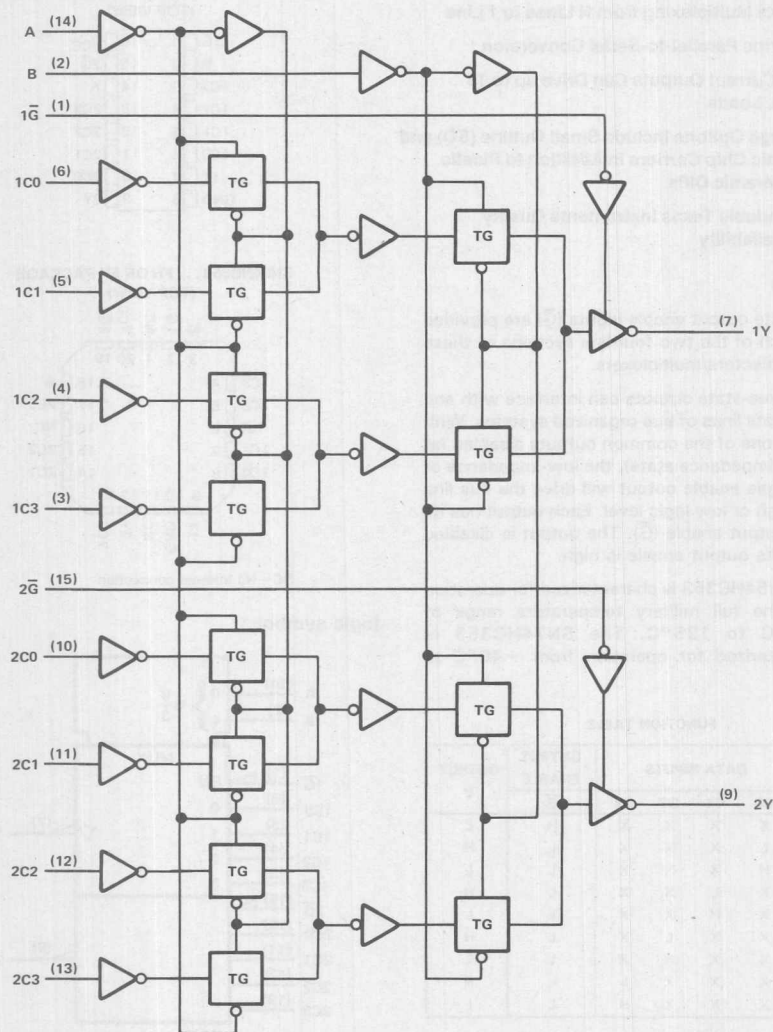
Pin numbers shown are for J and N packages.

3

3  
HCMOS DEVICES

**TYPES SN54HC353, SN74HC353**  
**DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS**  
**WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC353		SN74HC353		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		60	185		280		230	ns
			4.5 V		17	37		56		46	
			6 V		14	32		48		39	
$t_{pd}$	Data (Any C)	Y	2 V		48	175		265		220	ns
			4.5 V		14	35		53		44	
			6 V		11	30		45		37	
$t_{en}$	$\overline{G}$	Y	2 V		37	135		205		170	ns
			4.5 V		11	27		41		34	
			6 V		9	23		35		29	
$t_{dis}$	$\overline{G}$	Y	2 V		22	135		205		170	ns
			4.5 V		13	27		41		34	
			6 V		11	23		35		29	
$t_t$		Any	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per multiplexer	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC353		SN74HC353		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		75	270		410		335	ns
			4.5 V		21	54		82		67	
			6 V		18	47		70		58	
$t_{pd}$	Data (Any C)	Y	2 V		67	260		395		325	ns
			4.5 V		19	52		79		63	
			6 V		16	45		67		56	
$t_{en}$	$\overline{G}$	Y	2 V		54	220		335		275	ns
			4.5 V		16	44		67		55	
			6 V		14	38		57		48	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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HCMOS DEVICES





## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC365 THRU SN54HC368 SN74HC365 THRU SN74HC368 HEX BUS DRIVERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- High-Current 3-State Outputs Drive Bus Lines, Buffer Memory Address Registers, or up to 15 LSTTL Loads
- Choice of True or Inverting Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

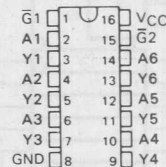
'HC365, 'HC367 True Outputs  
'HC366, 'HC368 Inverting Outputs

### description

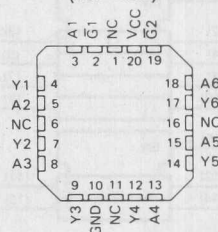
These Hex buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. The designer has a choice of selected combinations of inverting and noninverting outputs, symmetrical G (active-low control) inputs.

The SN54HC' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

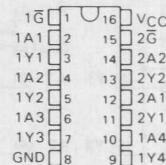
SN54HC365, SN54HC366... J PACKAGE  
SN74HC365, SN74HC366... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



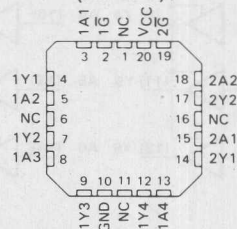
SN54HC365, SN54HC366... FH OR FK PACKAGE  
(TOP VIEW)



SN54HC367, SN54HC368... J PACKAGE  
SN74HC367, SN74HC368... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC367, SN54HC368... FH OR FK PACKAGE  
(TOP VIEW)



maximum ratings, recommended operation conditions,  
and electrical characteristics

See Table III, page 2-8.

NC—No internal connection

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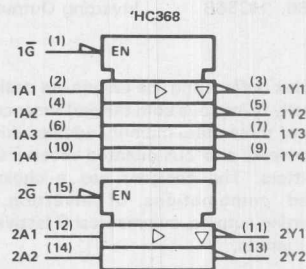
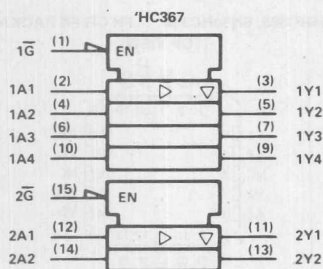
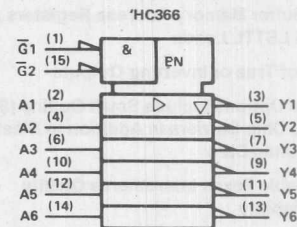
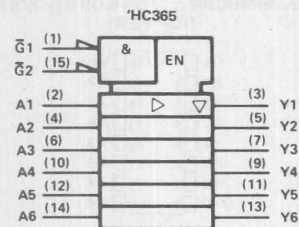
TEXAS  
INSTRUMENTS

3

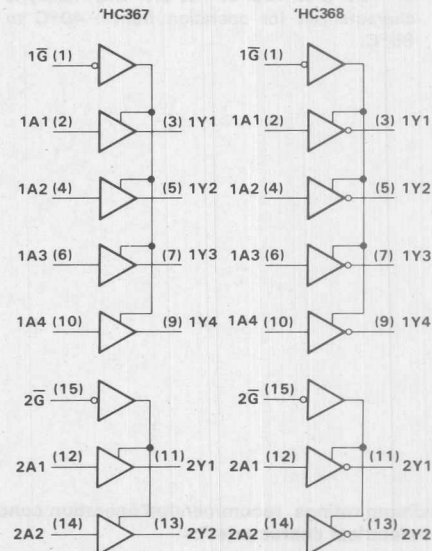
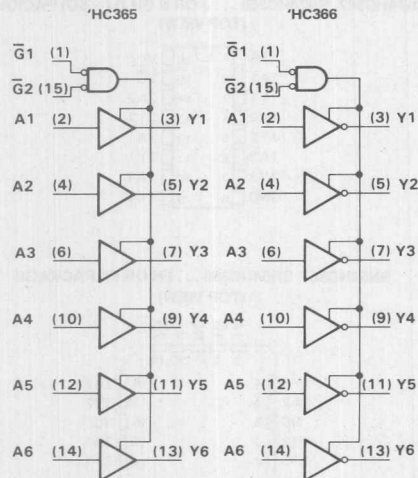
HCMOS DEVICES

**TYPES SN54HC365 THRU SN54HC368  
SN74HC365 THRU SN74HC368  
HEX BUS DRIVERS WITH 3-STATE OUTPUTS**

**logic symbols**



**logic diagrams (positive logic)**



Pin numbers shown are for J and N packages.

**3**

**HCMOS DEVICES**

**TYPES SN54HC365 THRU SN54HC368  
SN74HC365 THRU SN74HC368  
HEX BUS DRIVERS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC'		SN74HC'		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		50	95		145		120	ns
			4.5 V		12	19		29		24	
			6 V		10	16		25		20	
$t_{en}$	$\bar{G}$	Y	2 V		100	190		285		238	ns
			4.5 V		26	38		57		48	
			6 V		21	32		48		41	
$t_{dis}$	$\bar{G}$	Y	2 V		50	175		265		240	ns
			4.5 V		21	35		53		48	
			6 V		19	30		45		41	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per driver	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC'		SN74HC'		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		70	120		180		150	ns
			4.5 V		17	24		36		30	
			6 V		14	20		31		25	
$t_{en}$	$\bar{G}$	Y	2 V		140	230		345		285	ns
			4.5 V		30	46		69		57	
			6 V		28	39		59		48	
$t_t$			2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# 3

## HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC373, SN74HC373 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8 High-Current Latches in a Single Package
- High-Current 3-State True Outputs Can Drive up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

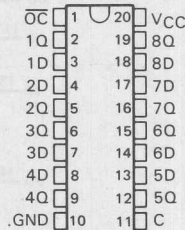
The eight latches of the 'HC373 are transparent D-type latches. While the enable (C) is high the Q outputs will follow the data (D) inputs. When the enable is taken low, the Q outputs will be latched at the levels that were set up at the D inputs.

An output-control input ( $\overline{OC}$ ) can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

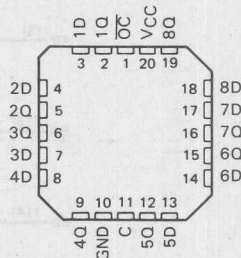
The output control  $\overline{OC}$  does not affect the internal operations of the latches. Old data can be retained or new data can be entered while the outputs are off.

The SN54HC373 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC373 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

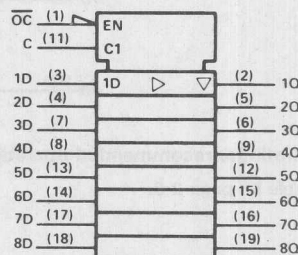
SN54HC373 ... J PACKAGE  
SN74HC373 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC373 ... FH OR FK PACKAGE  
(TOP VIEW)



### logic symbol



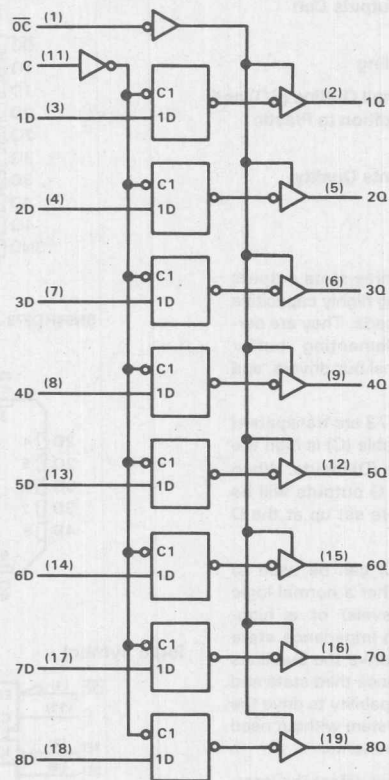
FUNCTION TABLE (EACH LATCH)

INPUTS			OUTPUT
$\overline{OC}$	ENABLE C	D	Q
L	H	H	H
L	H	L	L
L	L	X	$Q_0$
H	X	X	Z

3

HCMOS DEVICES

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.



# TYPES SN54HC373, SN74HC373 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC373		SN74HC373		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before enable C↓	2 V	50		75		63		ns
	4.5 V	10		15		13		
	6 V	9		13		11		
t <sub>h</sub> Hold time, data after enable C↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC373		SN74HC373		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	2 V		58	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>pd</sub>	C	Any Q	2 V		73	175		265		220	ns
			4.5 V		18	35		53		44	
			6 V		15	30		45		38	
t <sub>en</sub>	$\overline{OC}$	Any Q	2 V		65	150		225		190	ns
			4.5 V		17	30		45		38	
			6 V		14	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any Q	2 V		50	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25 °C	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# TYPES SN54HC373, SN74HC373

## OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

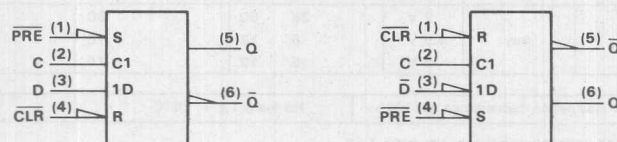
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC373			SN74HC373			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
$t_{pd}$	D	Q	2 V	82	200		300		250				ns
			4.5 V	22	40		60		50				
			6 V	19	34		51		43				
$t_{pd}$	C	Any Q	2 V	100	225		335		285				ns
			4.5 V	24	45		67		57				
			6 V	20	38		57		48				
$t_{en}$	$\overline{OC}$	Any Q	2 V	90	200		300		250				ns
			4.5 V	23	40		60		50				
			6 V	19	34		51		43				
$t_t$		Any	2 V	45	210		315		265				ns
			4.5 V	17	42		63		53				
			6 V	13	36		53		45				

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

### D latch signal conventions

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a Q output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators ( $\triangle$ ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q, and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input D, but now both are considered active low.

3

HC MOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC374, SN74HC374 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8 D-Type Flip-Flops in a Single Package
- High-Current 3-State True Outputs Can Drive up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit flip-flops feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight flip-flops of the 'HC374 are edge-triggered D-type flip-flops. On the positive transition of the clock the Q outputs will be set to the logic levels that were set up at the D inputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

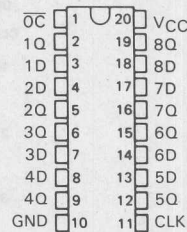
The output control ( $\overline{OC}$ ) does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HC374 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC374 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

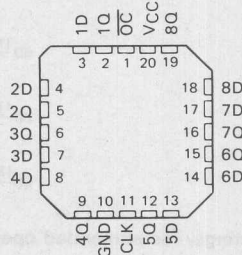
FUNCTION TABLE (EACH FLIP-FLOP)

INPUTS			OUTPUT
$\overline{OC}$	CLK	D	Q
L	$\uparrow$	H	H
L	$\uparrow$	L	L
L	L	X	$Q_0$
H	X	X	Z

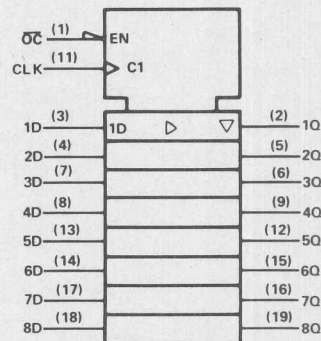
SN54HC374 ... J PACKAGE  
SN74HC374 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC374 ... FH OR FK PACKAGE  
(TOP VIEW)



### logic symbol

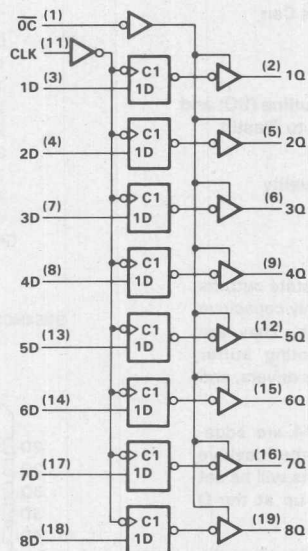


3

HCMOS DEVICES

**TYPES SN54HC374, SN74HC374**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS**  
**WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

3

HCMOS DEVICES

**TYPES SN54HC374, SN74HC374**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS**  
**WITH 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC374		SN74HC374		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	6	0	4	0	5	MHz
			4.5 V	0	30	0	20	0	24	
			6 V	0	35	0	24	0	28	
t <sub>w</sub>	Pulse duration	CLK high or low	2 V	80		120		100		ns
			4.5 V	16		24		20		
			6 V	14		20		17		
t <sub>su</sub>	Setup time, data before CLK ↑		2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		25		21		
t <sub>h</sub>	Hold time, data after CLK ↑		2 V	5		5		5		ns
			4.5 V	5		5		5		
			6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC374		SN74HC374		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	12		4		5		MHz
			4.5 V	30	60		20		24		
			6 V	35	70		24		28		
t <sub>pd</sub>	CLK	Any	2 V		63	180		270		225	ns
			4.5 V		17	36		54		45	
			6 V		15	31		46		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		60	150		225		190	ns
			4.5 V		16	30		45		38	
			6 V		14	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		36	150		225		190	ns
			4.5 V		17	30		45		38	
			6 V		16	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# **TYPES SN54HC374, SN74HC374** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC374		SN74HC374		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	6	12		4		5		MHz
			4.5 V	30	60		20		24		
			6 V	35	70		24		28		
$t_{pd}$	CLK	Any	2 V		80	230		345		290	ns
			4.5 V		22	46		69		58	
			6 V		19	39		58		49	
$t_{en}$	$\overline{OC}$	Any	2 V		70	200		300		250	ns
			4.5 V		25	40		60		50	
			6 V		22	34		51		43	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

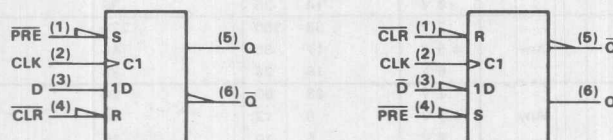
3

HCMOS DEVICES

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a  $\overline{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q, and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input  $\overline{D}$ , but now both are considered active-low.



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC377, SN54HC378, SN54HC379 SN74HC377, SN74HC378, SN74HC379 OCTAL, HEX, AND QUAD D-TYPE FLIP-FLOPS WITH CLOCK ENABLE

D2684, DECEMBER 1982—REVISED MARCH 1984

- 'HC377 and 'HC378 Contain Eight and Six Flip-Flops, Respectively, with Single-Rail Outputs
- 'HC379 Contains Four Flip-Flops with Double-Rail Outputs
- Clock Enable Latched to Avoid False Clocking
- Applications Include:  
Buffer/Storage Registers  
Shift Registers  
Pattern Generators
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

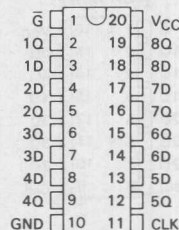
### description

These circuits are positive-edge-triggered D-type flip-flops with an enable input. The 'HC377, 'HC378, and 'HC379 devices are similar to 'HC273, 'HC174, and 'HC175 respectively, but feature a latched clock enable ( $\bar{G}$ ) instead of a common clear.

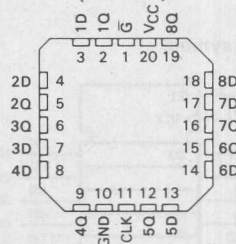
Information at the D inputs meeting the setup time requirements is transferred to the Q outputs on the positive-going edge of the clock pulse if  $\bar{G}$  is low. Clock triggering occurs at a particular voltage level and is not directly related to the transition time of the positive-going pulse. When the clock input is at either the high or low level, the D input signal has no effect at the output. The circuits are designed to prevent false clocking by transitions at the  $\bar{G}$  input.

The SN54HC377, SN54HC378, and SN54HC379 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC377, SN74HC378, and SN74HC379 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

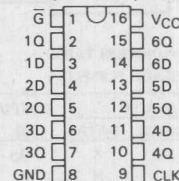
SN54HC377...J PACKAGE  
SN74HC377...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



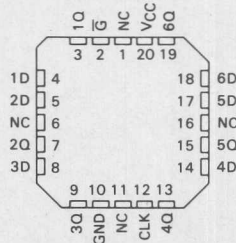
SN54HC377...FH OR FK PACKAGE  
(TOP VIEW)



SN54HC378...J PACKAGE  
SN74HC378...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC378...FH OR FK PACKAGE  
(TOP VIEW)



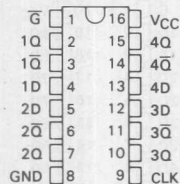
NC—No internal connection

3

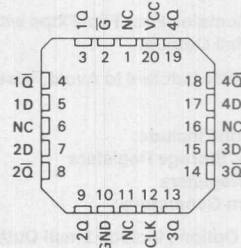
HCMOS DEVICES

# **TYPES SN54HC377, SN54HC379, SN74HC377, SN74HC379** **OCTAL AND QUAD D-TYPE FLIP-FLOPS WITH CLOCK ENABLE**

SN54HC379 ... J PACKAGE  
 SN74HC379 ... J OR N OR D (= SO) PACKAGE  
 (TOP VIEW)



SN54HC379 ... FH OR FK PACKAGE  
 (TOP VIEW)

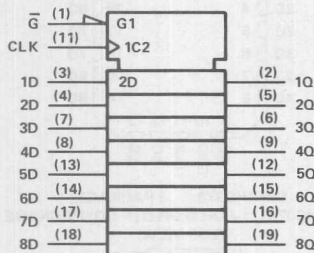


NC—No internal connection

3

HC MOS DEVICES

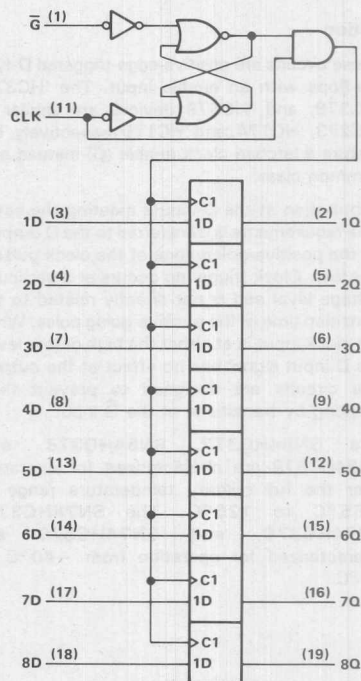
'HC377 logic symbol



FUNCTION TABLE  
 (EACH FLIP-FLOP)

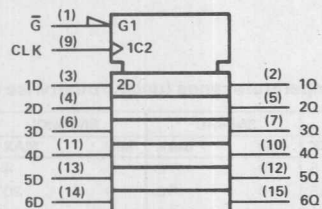
INPUTS			OUTPUT
Ḡ	CLOCK	DATA	Q
H	X	X	Q <sub>0</sub>
L	↑	H	H
L	↑	L	L
X	L	X	Q <sub>0</sub>

'HC377 logic diagram (positive logic)



# TYPES SN54HC378, SN54HC379, SN74HC378, SN74HC379 HEX AND QUAD D-TYPE FLIP-FLOPS WITH CLOCK ENABLE

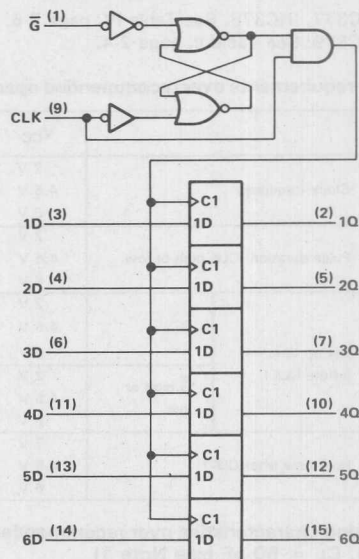
'HC378 logic symbol



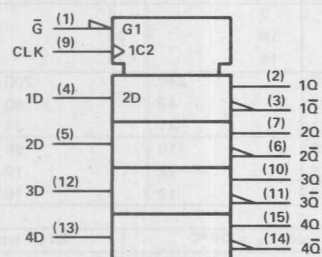
FUNCTION TABLE  
(EACH FLIP-FLOP)

INPUTS			OUTPUT
$\bar{G}$	CLOCK	DATA	Q
H	X	X	$Q_0$
L	↑	H	H
L	↑	L	L
X	L	X	$Q_0$

'HC378 logic diagram (positive logic)



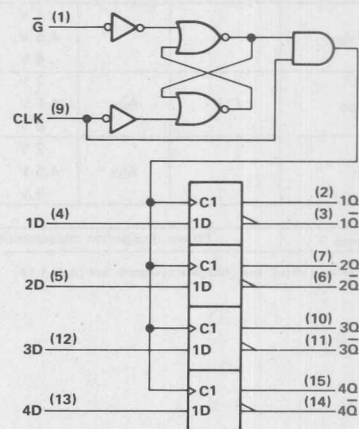
'HC379 logic symbol



FUNCTION TABLE  
(EACH FLIP-FLOP)

INPUTS			OUTPUTS	
$\bar{G}$	CLOCK	DATA	Q	$\bar{Q}$
H	X	X	$Q_0$	$\bar{Q}_0$
L	↑	H	H	L
L	↑	L	L	H
X	L	X	$Q_0$	$\bar{Q}_0$

'HC379 logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

HCNOS DEVICES

**TYPES SN54HC377, SN54HC378, SN54HC379  
SN74HC377, SN74HC378, SN74HC379  
OCTAL, HEX, AND QUAD D-TYPE FLIP-FLOPS WITH CLOCK ENABLE**

maximum ratings, recommended operating conditions, and electrical characteristics

'HC377, 'HC378: See Table IV, page 2-6.

'HC379: See Table II, page 2-4.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC'		SN74HC'		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5		0	3	0	4	MHz
		4.5 V	0	25		0	16	0	20	
		6 V	0	29		0	19	0	23	
t <sub>w</sub>	Pulse duration, CLK high or low	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			25		21		
t <sub>su</sub>	Set up time before CLK ↑	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			25		21		
	$\overline{G}$ high or low	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			25		21		
t <sub>h</sub>	Hold time after CLK ↑	2 V	0			0		0		ns
		4.5 V	0			0		0		
		6 V	0			0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC'		SN74HC'		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	11		3		4		MHz
			4.5 V	25	54		16		20		
			6 V	29	64		19		23		
t <sub>pd</sub>	CLK	Any	2 V		56	160		240		200	ns
			4.5 V		15	32		48		40	
			6 V		12	27		41		34	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	30 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

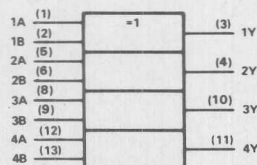
### description

These devices contain four independent 2-input Exclusive-OR gates. They perform the Boolean functions  $Y = A \oplus B = \overline{A}B + A\overline{B}$  in positive logic.

A common application is as a true/complement element. If one of the inputs is low, the other input will be reproduced in true form at the output. If one of the inputs is high, the signal on the other input will be reproduced inverted at the output.

The SN54HC386 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC386 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol



**FUNCTION TABLE**  
(each gate)

INPUTS		OUTPUT
A	B	Y
L	L	L
L	H	H
H	L	H
H	H	L

Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

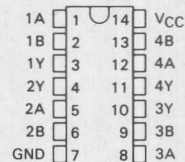
switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC386		SN74HC386		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V	40	100		150		125		ns
			4.5 V		12	20		30		25	
			6 V		10	17		25		21	
$t_t$		Y	2 V	28	75		110		95		ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

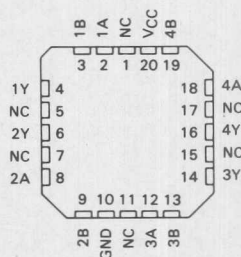
$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

SN54HC386...J PACKAGE  
SN74HC386...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC386...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection





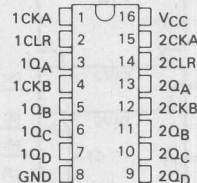
- 'HC390 . . . Individual Clock for A and B Flip-Flops Provide Dual +2 and +5 Counters
- 'HC393 . . . Dual 4-Bit Binary Counter with Individual Clocks
- All Have Direct Clear for Each 4-Bit Counter
- Dual 4-Bit Versions Can Significantly Improve System Densities by Reducing Counter Package Count by 50%
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

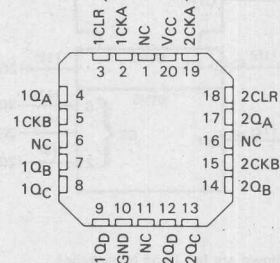
Each of these monolithic circuits contains eight flip-flops and additional gating to implement two individual four-bit counters in a single package. The 'HC390 incorporates dual divide-by-two and divide-by-five counters, which can be used to implement cycle lengths equal to any whole and/or cumulative multiples of 2 and/or 5 up to divide-by-100. When connected as a biquinary counter, the separate divide-by-two circuit can be used to provide symmetry (a square wave) at the final output stage. The 'HC393 comprises two independent four-bit binary counters each having a clear and a clock input. N-bit binary counters can be implemented with each package providing the capability of divide-by-256. The 'HC390 and 'HC393 have parallel outputs from each counter stage so that any submultiple of the input count frequency is available for system-timing signals.

The SN54HC390 and SN54HC393 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC390 and SN74HC393 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

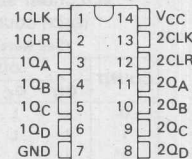
SN54HC390 . . . J PACKAGE  
SN74HC390 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



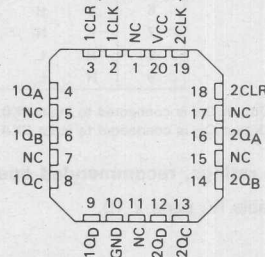
SN54HC390 . . . FH OR FK PACKAGE  
(TOP VIEW)



SN54HC393 . . . J PACKAGE  
SN74HC393 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC393 . . . FH OR FK PACKAGE  
(TOP VIEW)



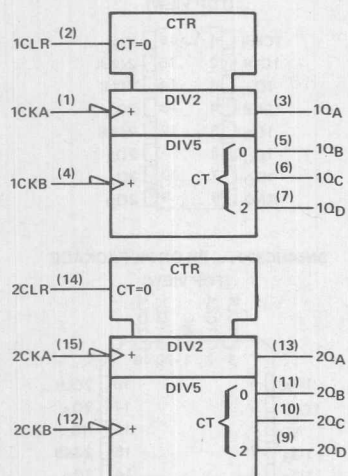
NC—No internal connection

3

HCMOS DEVICES

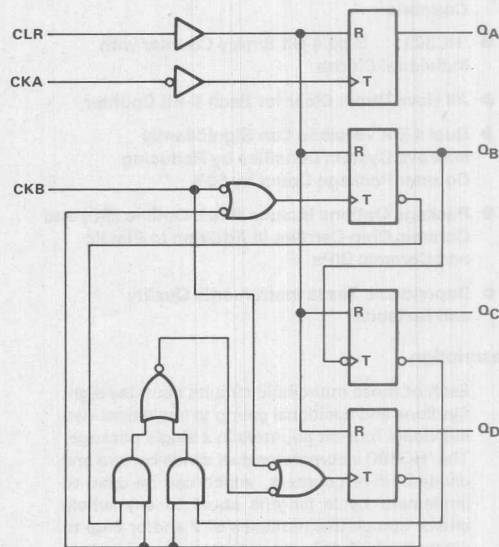
# TYPES SN54HC390, SN74HC390 DUAL 4-BIT DECADE COUNTERS

logic symbol



Pin numbers shown are for J and N packages.

logic diagram, each counter (positive logic)



FUNCTION TABLES

BCD COUNT SEQUENCE  
(EACH COUNTER)  
(See Note A)

COUNT	OUTPUT			
	Q <sub>D</sub>	Q <sub>C</sub>	Q <sub>B</sub>	Q <sub>A</sub>
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H

BIQUINARY (5-2)  
(EACH COUNTER)  
(See Note B)

COUNT	OUTPUT			
	Q <sub>A</sub>	Q <sub>D</sub>	Q <sub>C</sub>	Q <sub>B</sub>
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	H	L	L	L
6	H	L	L	H
7	H	L	H	L
8	H	L	H	H
9	H	H	L	L

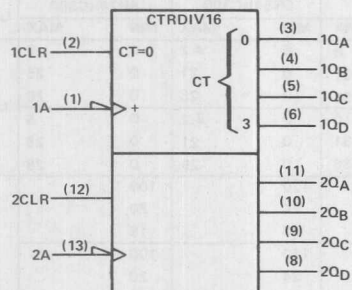
NOTES: A. Output Q<sub>A</sub> is connected to input CKB for BCD count.  
B. Output Q<sub>D</sub> is connected to input CKA for biquinary count.

maximum ratings, recommended operating conditions, and electrical characteristics

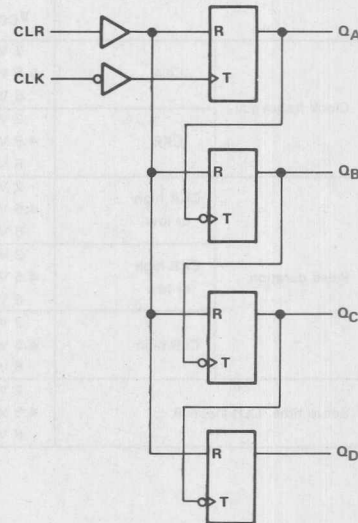
See Table IV, page 2-10.

# TYPES SN54HC393, SN74HC393 DUAL 4-BIT BINARY COUNTERS

logic symbol



logic diagram, each counter (positive logic)



Pin numbers shown are for J and N packages.

FUNCTION TABLE  
COUNT SEQUENCE  
(EACH COUNTER)

COUNT	OUTPUT			
	Q <sub>D</sub>	Q <sub>C</sub>	Q <sub>B</sub>	Q <sub>A</sub>
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H
10	H	L	H	L
11	H	L	H	H
12	H	H	L	L
13	H	H	L	H
14	H	H	H	L
15	H	H	H	H

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

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HCMOS DEVICES

TYPES SN54HC390, SN74HC390  
DUAL 4-BIT BINARY COUNTERS

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC390		SN74HC390		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	CKA	2 V	0	6	0	4.2	0	5	MHz
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	28	
	CKB	2 V	0	6	0	4.2	0	5	
		4.5 V	0	31	0	21	0	25	
		6 V	0	36	0	25	0	28	
t <sub>w</sub> Pulse duration	CKA high or low	2 V	80		120		100		ns
		4.5 V	16		24		20		
		6 V	14		20		18		
	CKB high or low	2 V	80		120		100		
		4.5 V	16		24		20		
		6 V	14		20		18		
	CLR high	2 V	80		120		100		
		4.5 V	16		24		20		
		6 V	14		20		18		
t <sub>su</sub> Setup time, CLR inactive			2 V	25	25		25		ns
			4.5 V	5	5		5		
			6 V	5	5		5		

3

HCMOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC390		SN74HC390		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$	CKA	$Q_A$	2 V	6	10		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		28		
	CKB	$Q_B$	2 V	6	10		4.2		5		
			4.5 V	31	50		21		25		
			6 V	36	60		25		28		
$t_{\text{pd}}$	CKA	$Q_A$	2 V		50	120		180		150	ns
			4.5 V		16	24		35		30	
			6 V		13	20		31		26	
$t_{\text{pd}}$	CKA	$Q_C$	2 V		100	290		430		365	ns
			4.5 V		35	58		87		72	
			6 V		30	50		74		62	
$t_{\text{pd}}$	CKB	$Q_B$	2 V		58	130		195		165	ns
			4.5 V		18	26		39		33	
			6 V		15	22		33		28	
$t_{\text{pd}}$	CKB	$Q_C$	2 V		83	185		280		230	ns
			4.5 V		26	37		55		46	
			6 V		21	32		48		40	
$t_{\text{pd}}$	CKB	$Q_D$	2 V		60	130		195		160	ns
			4.5 V		18	26		39		33	
			6 V		14	22		33		28	
$t_{\text{PHL}}$	CLR	Any	2 V		45	165		250		205	ns
			4.5 V		17	33		49		41	
			6 V		14	28		42		35	
$t_t$		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{\text{pd}}$	Power dissipation capacitance per counter	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HC393, SN74HC393** **DUAL 4-BIT BINARY COUNTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC393		SN74HC393		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	CLK	2 V	0	6	0	4.2	0	5	MHz
			4.5 V	0	31	0	21	0	25	
			6 V	0	36	0	25	0	28	
t <sub>w</sub>	Pulse duration	CLK high or low	2 V	80		120		100		ns
			4.5 V	16		24		20		
			6 V	14		20		18		
		CLR high	2 V	80		120		100		
			4.5 V	16		24		20		
			6 V	14		20		18		
t <sub>su</sub>	Setup time, CLR inactive	2 V	25		25		25		ns	
		4.5 V	5		5		5			
		6 V	5		5		5			

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC393		SN74HC393		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>	CLK	Q <sub>A</sub>	2 V	6	10		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	60		25		28		
t <sub>pd</sub>	CLK	Q <sub>A</sub>	2 V		50	120		180		150	ns
			4.5 V		15	24		36		30	
			6 V		13	20		31		26	
t <sub>pd</sub>	CLK	Q <sub>D</sub>	2 V		100	290		430		360	ns
			4.5 V		32	58		87		72	
			6 V		24	50		74		62	
t <sub>PHL</sub>	CLR	Any	2 V		45	165		250		205	ns
			4.5 V		17	33		49		41	
			6 V		14	28		42		35	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per counter	No load, T <sub>A</sub> = 25°C	40 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3  
HCMOS DEVICES



D2684, DECEMBER 1982—REVISED MARCH 1984

- Individual Clock, Direct Clear, and Set-to-9 Inputs for Each Decade Counter
- Dual Counters Can Significantly Improve System Densities as Package Count Can be Reduced by 50%
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

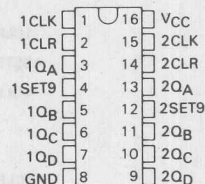
Each of these monolithic circuits contains eight master-slave flip-flops and additional gating to implement two individual 4-bit decade counters in a single package. Each decade counter has individual clock, clear, and set-to-9 inputs. BCD count sequences of any length up to divide-by-100 may be implemented with a single 'HC490. The counters have parallel outputs from each counter stage so that submultiples of the input count frequency are available for system timing signals.

The SN54HC490 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC490 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

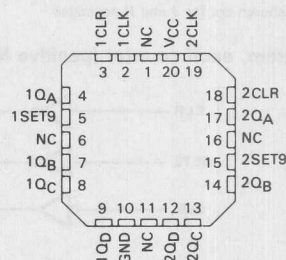
CLEAR/SET-TO-9  
FUNCTION TABLE  
(EACH COUNTER)

INPUTS		OUTPUTS			
CLEAR	SET-TO-9	Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>
H	L	L	L	L	L
L	H	H	L	L	H
L	L	COUNT			

SN54HC490... J PACKAGE  
SN74HC490... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC490... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

BCD COUNT SEQUENCE  
(EACH COUNTER)

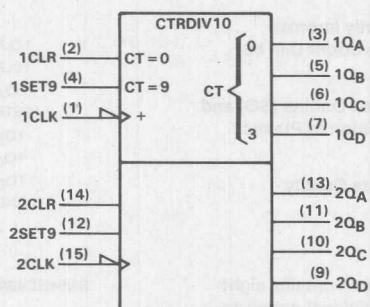
COUNT	OUTPUT			
	Q <sub>D</sub>	Q <sub>C</sub>	Q <sub>B</sub>	Q <sub>A</sub>
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H

3

HCMOS DEVICES

# TYPES SN54HC490, SN74HC490 DUAL 4-BIT DECADE COUNTERS

logic symbol

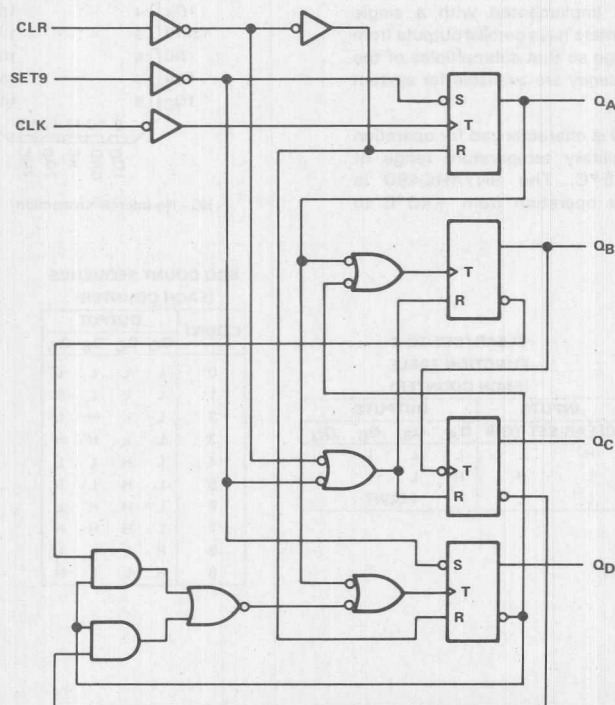


Pin numbers shown are for J and N packages.

3

logic diagram, each counter (positive logic)

HCMOS DEVICES



# **TYPES SN54HC490, SN74HC490** **DUAL 4-BIT DECADE COUNTERS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC490		SN74HC490		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	2 V	0	6	0	4.2	0	5	MHz
	4.5 V	0	31	0	21	0	25	
	6 V	0	36	0	25	0	28	
t <sub>w</sub> Pulse duration, any input	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		18		
t <sub>su</sub> Setup time, CLR or set-to-9 inactive	2 V	25		25		25		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC490		SN74HC490		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6			4.2		5		MHz
			4.5 V	31			21		25		
			6 V	36			25		28		
t <sub>pd</sub>	CLK	Q <sub>A</sub>	2 V		50	125		190		155	ns
			4.5 V		15	25		38		31	
			6 V		12	21		32		26	
	CLK	Q <sub>B</sub> , Q <sub>D</sub>	2 V		80	185		280		230	
			4.5 V		23	37		56		46	
			6 V		18	31		48		39	
	CLK	Q <sub>C</sub>	2 V		100	235		355		295	
			4.5 V		30	47		71		59	
			6 V		23	40		60		50	
t <sub>PLH</sub>	Set-to-9	Q <sub>A</sub> , Q <sub>D</sub>	2 V		60	185		280		230	ns
			4.5 V		19	37		56		46	
			6 V		16	31		48		39	
t <sub>PHL</sub>	Set-to-9	Q <sub>B</sub> , Q <sub>C</sub>	2 V		54	140		210		175	ns
			4.5 V		18	28		42		35	
			6 V		16	24		36		30	
	Clear	Any	2 V		50	130		195		165	
			4.5 V		17	26		39		33	
			6 V		15	22		33		28	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per counter	No load, T <sub>A</sub> = 25 °C	40 pF typ
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NOTE 1: For load circuits and voltage waveforms, see page 1-14.

### 3 HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

- High-Current 3-State Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight latches are transparent D-type latches. While the enable (C) is high the  $\bar{Q}$  outputs will follow the complements of data (D) inputs. When the enable is taken low the outputs will be latched at the inverses of the levels that were set up at the D inputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance state and increased high-logic level provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

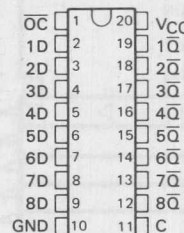
The output control ( $\bar{OC}$ ) does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HC563 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC563 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

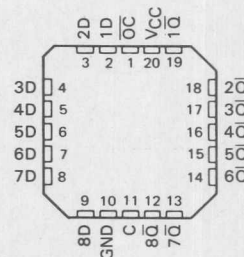
## TYPES SN54HC563, SN74HC563 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

SN54HC563 . . . J PACKAGE  
SN74HC563 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC563 . . . FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE  
(Each Latch)

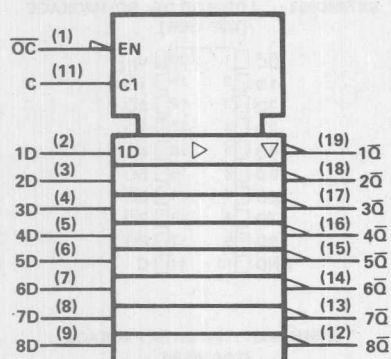
INPUTS			OUTPUT $\bar{Q}$
$\bar{OC}$	C	D	
L	H	H	L
L	H	L	H
L	L	X	$Q_0$
H	X	X	Z

3

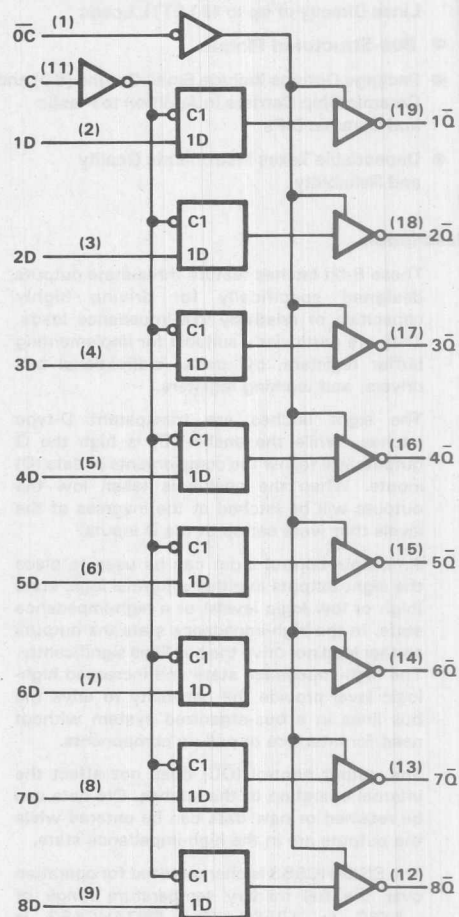
HCMOS DEVICES

**TYPES SN54HC563, SN74HC563**  
**OCTAL D-TYPE TRANSPARENT LATCHES**  
**WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



3

HCMOS DEVICES



# **TYPES SN54HC563, SN74HC563** **OCTAL D-TYPE TRANSPARENT LATCHES** **WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC563		SN74HC563		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before enable C ↓	2 V	50		75		63		ns
	4.5 V	10		15		13		
	6 V	9		13		11		
t <sub>h</sub> Hold time, data after enable C ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC563		SN74HC563		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	$\overline{Q}$	2 V		77	175		265		220	ns
			4.5 V		26	35		53		44	
			6 V		23	30		45		38	
t <sub>pd</sub>	C	Any	2 V		90	175		265		220	ns
			4.5 V		27	35		53		44	
			6 V		23	30		45		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		70	150		225		190	ns
			4.5 V		24	30		45		38	
			6 V		21	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		47	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		21	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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NOTE 1: For load circuits and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HC563, SN74HC563** **OCTAL D-TYPE TRANSPARENT LATCHES** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

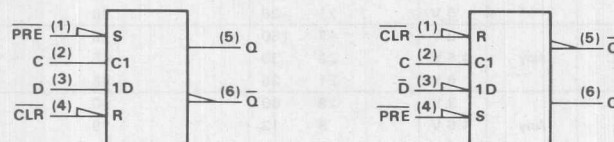
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC563		SN74HC563		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D	$\overline{Q}$	2 V		95	200		300		250	ns
			4.5 V		33	40		60		50	
			6 V		29	34		51		43	
$t_{pd}$	C	Any	2 V		103	225		335		285	ns
			4.5 V		33	45		67		57	
			6 V		29	38		57		48	
$t_{en}$	$\overline{OC}$	Any	2 V		85	200		300		250	ns
			4.5 V		29	40		60		50	
			6 V		26	34		51		43	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		53		45	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

## **D latch signal conventions**

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a  $\overline{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q, and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input  $\overline{D}$ , but now both are considered active-low.

- Inputs are TTL-Voltage Compatible
- High-Current 3-State Outputs Drive Bus-Lines Directly or up to 15 LSTTL-Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

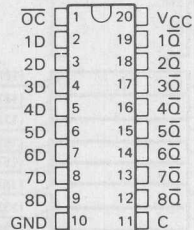
The eight latches are transparent D-type latches. While the enable (C) is high the  $\bar{Q}$  outputs will follow the complements of the data (D) inputs. When the enable is taken low the outputs will be latched at the inverses of the levels that were set up at the D inputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance state and increased high-logic level provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

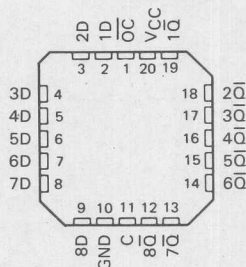
The output control ( $\bar{OC}$ ) does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HCT563 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT563 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT563 . . . J PACKAGE  
SN74HCT563 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT563 . . . FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE  
(Each Latch)

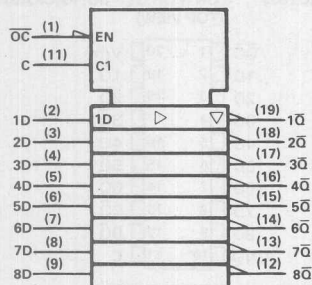
INPUTS			OUTPUT $\bar{Q}$
$\bar{OC}$	C	D	
L	H	H	L
L	H	L	H
L	L	X	$Q_0$
H	X	X	Z

3

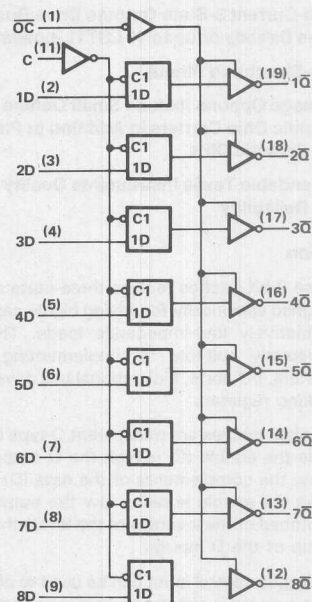
HCMOS DEVICES

# TYPES SN54HCT563, SN74HCT563 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

logic symbol



logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT563		SN74HCT563		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	4.5 V	20		30		25		ns
	5.5 V	17		27		23		
t <sub>su</sub> Setup time, data before enable C ↑	4.5 V	10		15		13		ns
	5.5 V	9		14		12		
t <sub>h</sub> Hold time, data after enable C ↓	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

3

HCMOS DEVICES

**TYPES SN54HCT563, SN74HCT563**  
**OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT563		SN74HCT563		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D	$\bar{Q}$	4.5 V		28	35		53		44	ns
			5.5 V		24	32		48		40	
$t_{pd}$	C	Any	4.5 V		30	35		53		44	ns
			5.5 V		28	32		48		40	
$t_{en}$	$\overline{OC}$	Any	4.5 V		29	35		53		44	ns
			5.5 V		25	32		48		40	
$t_{dis.}$	$\overline{OC}$	Any	4.5 V		25	35		53		44	ns
			5.5 V		24	32		48		40	
$t_t$		Any	4.5 V		10	12		18		15	ns
			5.5 V		9	11		16		14	

$C_{pd}$	Power dissipation capacitance per latch	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT563		SN74HCT563		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D	$\bar{Q}$	4.5 V		36	52		79		65	ns
			5.5 V		32	47		71		59	
$t_{pd}$	C	Any	4.5 V		40	52		79		65	ns
			5.5 V		38	47		71		59	
$t_{en}$	$\overline{OC}$	Any	4.5 V		35	52		79		65	ns
			5.5 V		29	47		71		59	
$t_t$		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

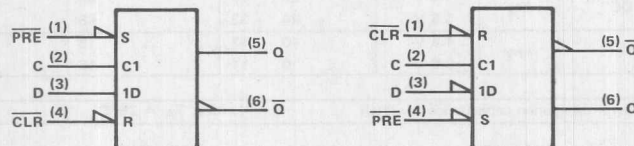
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3  
HCMOS DEVICES

### D latch signal conventions

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.



- High-Current 3-State Inverting Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit registers feature three-state outputs designed specifically for bus driving. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight-bit edge-triggered D-type flip-flops enter data on the low-to-high transition of the clock.

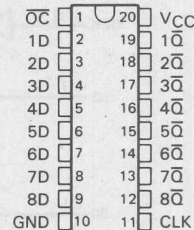
An output control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HC564 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC564 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

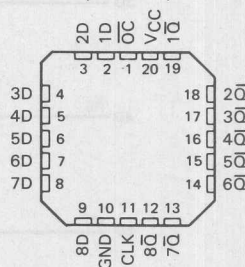
**FUNCTION TABLE  
(EACH FLIP-FLOP)**

INPUTS			OUTPUT
$\overline{\text{OC}}$	CLK	D	$\bar{\text{Q}}$
L	$\uparrow$	H	L
L	$\uparrow$	L	H
L	L	X	$\bar{\text{Q}}_0$
H	X	X	Z

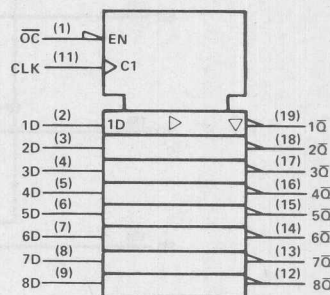
**SN54HC564 . . . J PACKAGE  
SN74HC564 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC564 . . . FH OR FK PACKAGE  
(TOP VIEW)**



### logic symbol

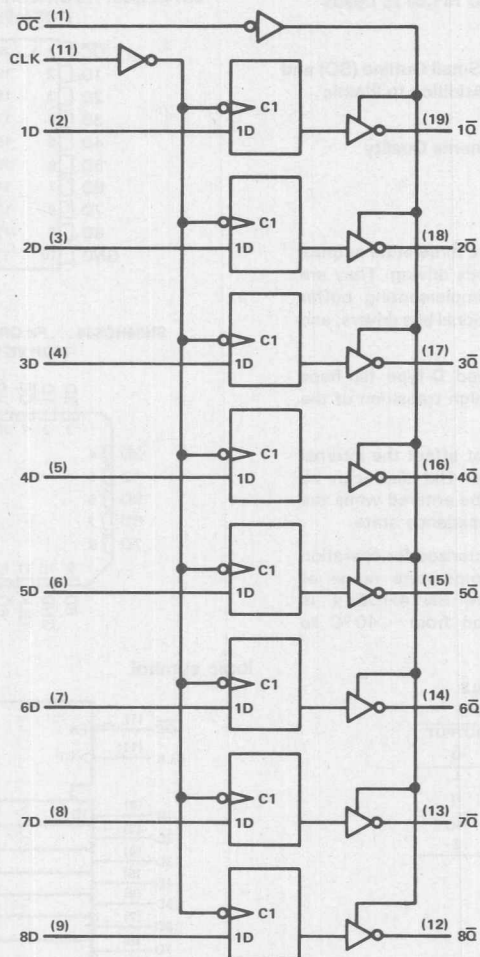


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HC MOS DEVICES

**TYPES SN54HC564, SN74HC564**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

# **TYPES SN54HC564 SN74HC564** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC564		SN74HC564		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	2 V	0	6	0	4.2	0	5	MHz
	4.5 V	0	31	0	21	0	25	
	6 V	0	36	0	25	0	29	
t <sub>w</sub> Pulse duration, CLK high or low	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before CLK ↑	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
t <sub>h</sub> Hold time, data after CLK ↑	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC564		SN74HC564		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	11		4.2		5		MHz
			4.5 V	31	36		21		25		
			6 V	36	40		25		29		
t <sub>pd</sub>	CLK	Any	2 V		54	180		270		225	ns
			4.5 V		18	36		54		45	
			6 V		15	31		46		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		45	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		45	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HC564 SN74HC564** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

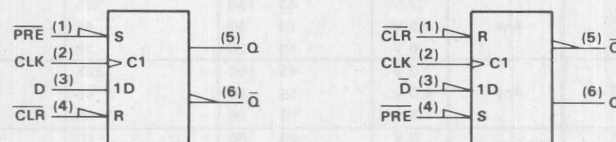
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC564		SN74HC564		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CLK	Any	2 V		75	230		345		290	ns
			4.5 V		24	46		69		58	
			6 V		21	34		58		49	
$t_{en}$	$\overline{OC}$	Any	2 V		57	200		300		250	ns
			4.5 V		19	40		60		50	
			6 V		17	34		51		43	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a  $\overline{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\overline{\phantom{x}}$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q, and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input  $\overline{D}$ , but now both are considered active-low.

- Inputs are TTL-Voltage Compatible
- High-Current 3-State Inverting Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These 8-bit registers feature three-state outputs designed specifically for bus driving. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight-bit edge-triggered D-type flip-flops enter data on the low-to-high transition of the clock.

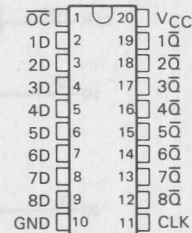
An output control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HCT564 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT564 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

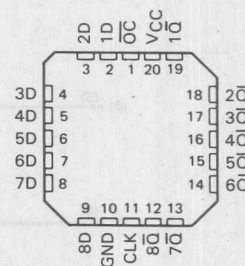
**FUNCTION TABLE  
(EACH FLIP-FLOP)**

INPUTS			OUTPUT
$\overline{\text{OC}}$	CLK	D	$\overline{\text{Q}}$
L	$\uparrow$	H	L
L	$\uparrow$	L	H
L	L	X	$\overline{\text{Q}}_0$
H	X	X	Z

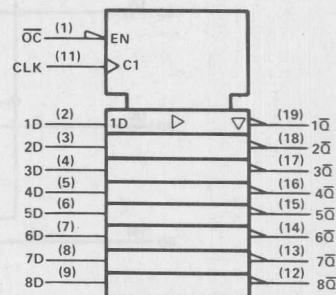
**SN54HCT564... J PACKAGE  
SN74HCT564... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HCT564... FH OR FK PACKAGE  
(TOP VIEW)**

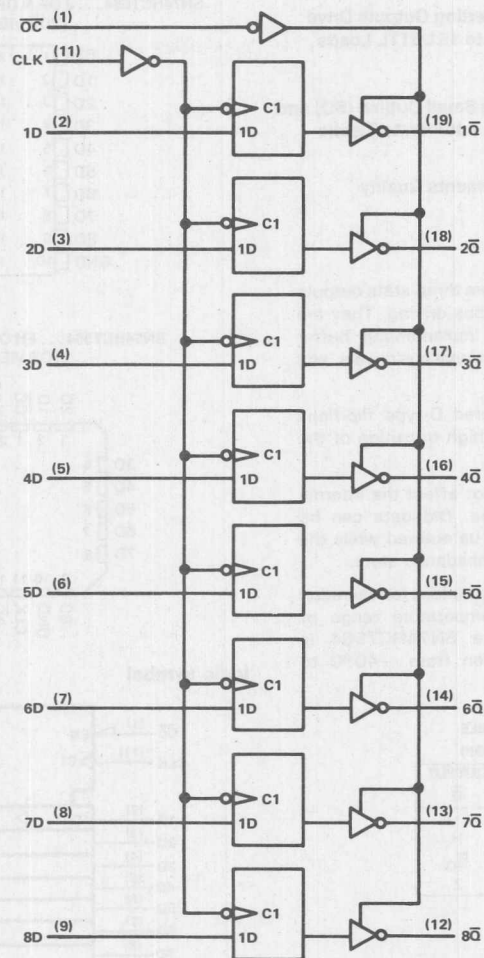


**logic symbol**



**TYPES SN54HCT564, SN74HCT564**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

3

HCMOS DEVICES



# **TYPES SN54HCT564 SN74HCT564** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT564		SN74HCT564		UNIT
		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	4.5 V	0		31		21		25	MHz
	5.5 V	0		36		23		28	
t <sub>w</sub> Pulse duration, CLK high or low	4.5 V		16		24		20		ns
	5.5 V		14		22		18		
t <sub>su</sub> Setup time, data before CLK ↑	4.5 V		20		30		25		ns
	5.5 V		17		27		23		
t <sub>h</sub> Hold time, data after CLK ↑	4.5 V		5		5		5		ns
	5.5 V		5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT564		SN74HCT564		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			4.5 V	31	36		21		25		MHz
			5.5 V	36	40		23		28		
t <sub>pd</sub>	CLK	Any	4.5 V		18	36		54		45	ns
			5.5 V		16	32		48		41	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		14	30		45		38	ns
			5.5 V		10	27		41		34	
t <sub>dis</sub>	$\overline{OC}$	Any	4.5 V		22	30		45		38	ns
			5.5 V		20	27		41		34	
t <sub>t</sub>		Any	4.5 V		10	12		18		15	ns
			5.5 V		9	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25 °C	93 pF typ
-----------------	---	---------------------------------	-----------

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT564		SN74HCT564		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CLK	Any	4.5 V		38	38		80		66	ns
			5.5 V		36	47		71		60	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		30	47		71		59	ns
			5.5 V		27	39		59		49	
t <sub>t</sub>		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

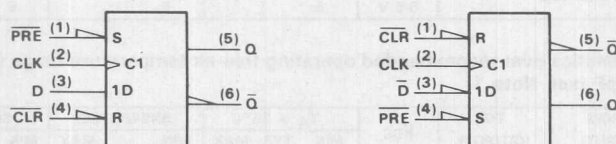
3  
HCMOS DEVICES

# **TYPES SN54HCT564 SN74HCT564** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called  $Q$  and those producing complementary data are called  $\bar{Q}$ . An input that causes a  $Q$  output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a  $Q$  output to go low is called Clear. Bars are used over these pin names (PRE and CLR) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that  $Q$  and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ ,  $Q$ , and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

3

HC MOS DEVICES

- High-Current 3-State Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight latches are transparent D-type latches. While the enable (C) is high the outputs (Q) will respond to the data (D) inputs. When the enable is taken low the outputs will be latched to retain the data that was set up.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

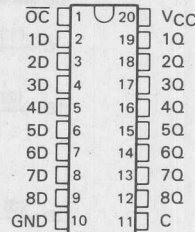
The output control ( $\overline{OC}$ ) does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are in the high impedance state.

The SN54HC573 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC573 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

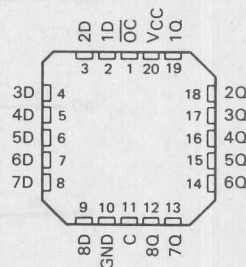
**FUNCTION TABLE  
(EACH LATCH)**

INPUTS			OUTPUT Q
ENABLE $\overline{OC}$	C	D	
L	H	H	H
L	H	L	L
L	L	X	$Q_0$
H	X	X	Z

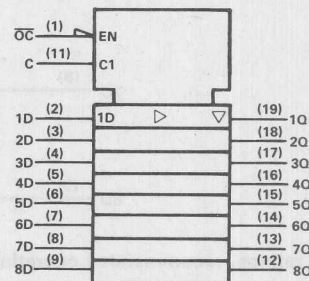
**SN54HC573 . . . J PACKAGE  
SN74HC573 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC573 . . . FH OR FK PACKAGE  
(TOP VIEW)**

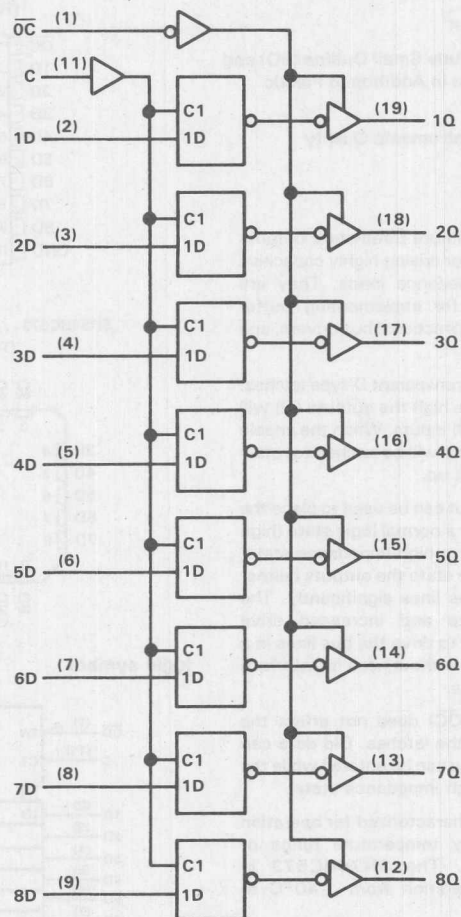


### logic symbol



**TYPES SN54HC573, SN74HC573**  
**OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

# **TYPES SN54HC573, SN74HC573** **OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC573		SN74HC573		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>W</sub> Pulse duration, C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before enable C↓	2 V	50		75		63		ns
	4.5 V	10		15		13		
	6 V	9		13		11		
t <sub>h</sub> Hold time, data after enable C↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC573		SN74HC573		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	2 V		77	175		265		220	ns
			4.5 V		26	35		53		44	
			6 V		23	30		45		38	
t <sub>pd</sub>	C	Any	2 V		87	175		265		220	ns
			4.5 V		27	35		53		44	
			6 V		23	30		45		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		68	150		225		190	ns
			4.5 V		24	30		45		38	
			6 V		21	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		47	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		21	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# TYPES SN54HC573, SN74HC573 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC573		SN74HC573		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D	Q	2 V		95	200		300		250	ns
			4.5 V		33	40		60		50	
			6 V		21	34		51		43	
$t_{pd}$	C	Any	2 V		103	225		335		285	ns
			4.5 V		33	45		67		57	
			6 V		29	38		57		48	
$t_{en}$	$\overline{OC}$	Any	2 V		85	200		300		250	ns
			4.5 V		29	40		60		50	
			6 V		26	34		51		43	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		53		45	

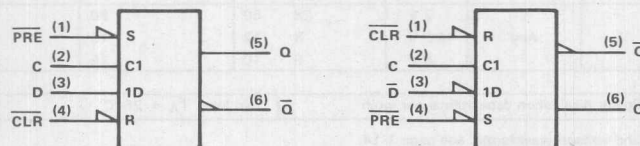
NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

## D latch signal conventions

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a  $\overline{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators ( $\triangle$ ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input  $\overline{D}$ , but now both are considered active-low.



- Inputs are TTL-Voltage Compatible
- High-Current 3-State Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight latches are transparent D-type latches. While the enable (C) is high the outputs (Q) will respond to the data (D) inputs. When the enable is taken low the outputs will be latched to retain the data that was set up.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

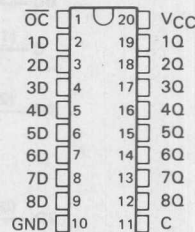
The output control ( $\overline{OC}$ ) does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are in the high impedance state.

The SN54HCT573 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT573 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

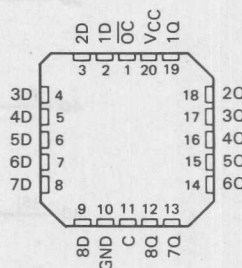
**FUNCTION TABLE  
(EACH LATCH)**

INPUTS			OUTPUT Q
ENABLE $\overline{OC}$	C	D	
L	H	H	H
L	H	L	L
L	L	X	$Q_0$
H	X	X	Z

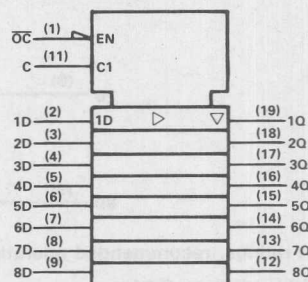
**SN54HCT573 ... J PACKAGE  
SN74HCT573 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HCT573 ... FH OR FK PACKAGE  
(TOP VIEW)**

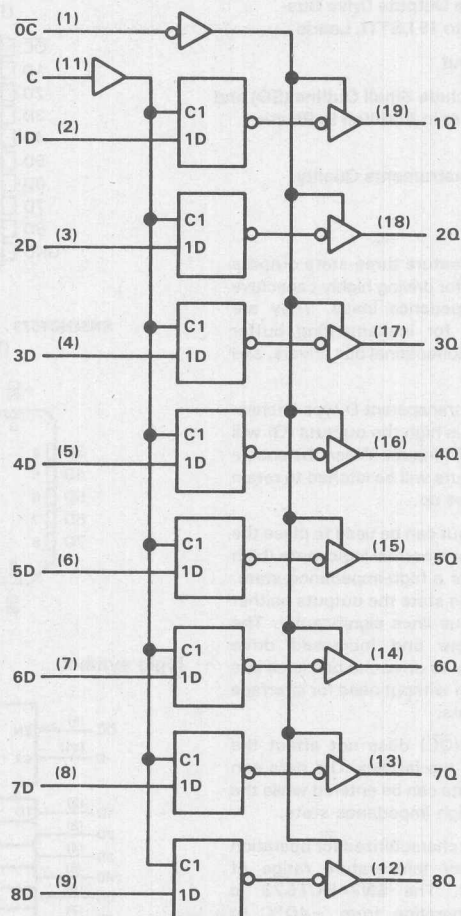


**logic symbol**



**TYPES SN54HCT573, SN74HCT573**  
**OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

**3**

**HCMOS DEVICES**

# TYPES SN54HCT573, SN74HCT573 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT573		SN74HCT573		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, C high	4.5 V	20		30		25		ns
	5.5 V	17		27		23		
t <sub>su</sub> Setup time, data before enable C ↓	4.5 V	10		15		13		ns
	5.5 V	9		14		12		
t <sub>h</sub> Hold time, data after enable C ↓	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT573		SN74HCT573		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	4.5 V		25	35		53		44	ns
			5.5 V		21	32		48		40	
t <sub>pd</sub>	C	Any	4.5 V		28	35		53		44	ns
			5.5 V		25	32		48		40	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		26	35		53		44	ns
			5.5 V		23	32		48		40	
t <sub>dis</sub>	$\overline{OC}$	Any	4.5 V		23	35		53		44	ns
			5.5 V		22	32		48		40	
t <sub>t</sub>		Any	4.5 V		9	12		18		15	ns
			5.5 V		9	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT573		SN74HCT573		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	4.5 V		32	52		79		65	ns
			5.5 V		27	47		71		59	
t <sub>pd</sub>	C	Any	4.5 V		38	52		79		65	ns
			5.5 V		36	47		71		59	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		33	52		79		65	ns
			5.5 V		28	47		71		59	
t <sub>t</sub>		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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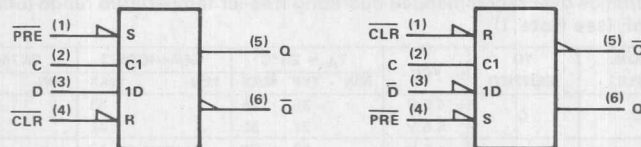
HCMOS DEVICES

## TYPES SN54HCT573, SN74HCT573 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

### D latch signal conventions

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

- High-Current 3-State Noninverting Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These 8-bit registers feature three-state outputs designed specifically for bus driving. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight edge-triggered D-type flip-flops enter data on the low-to-high transition of the clock.

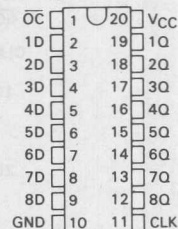
The output-control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HC574 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC574 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

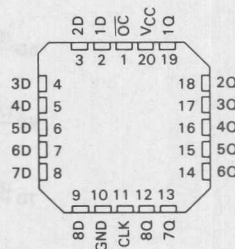
**FUNCTION TABLE  
(EACH FLIP-FLOP)**

INPUTS			OUTPUT
OC	CLK	D	Q
L	1	H	H
L	1	L	L
L	L	X	Q <sub>O</sub>
H	X	X	Z

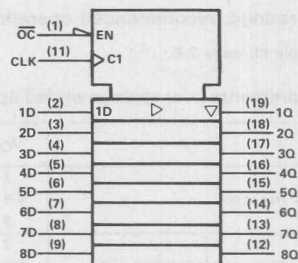
**SN54HC574...J PACKAGE  
SN74HC574...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC574...FH OR FK PACKAGE  
(TOP VIEW)**

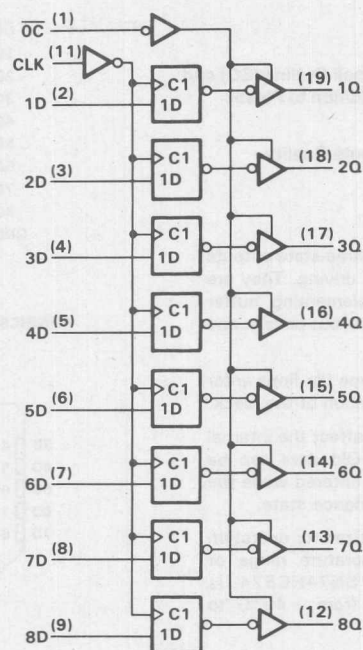


**logic symbol**



# **TYPES SN54HC574, SN74HC574** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC574		SN74HC574		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	6	0	4	0	5	MHz
			4.5 V	0	30	0	20	0	24	
			6 V	0	36	0	24	0	28	
t <sub>W</sub>	Pulse duration	CLK high or low	2 V	80	120	100				ns
			4.5 V	16	24	20				
			6 V	14	20	17				
t <sub>su</sub>	Setup time, data before CLK ↑		2 V	100	150	125			ns	
			4.5 V	20	30	25				
			6 V	17	26	21				
t <sub>h</sub>	Hold time, data after CLK ↑		2 V	5	5	5			ns	
			4.5 V	5	5	5				
			6 V	5	5	5				



# **TYPES SN54HC574, SN74HC574** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC574		SN74HC574		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	6	11		4		5		MHz
			4.5 V	30	36		20		24		
			6 V	36	40		24		28		
$t_{\text{pd}}$	CLK	Any	2 V		90	180		270		225	ns
			4.5 V		28	36		54		45	
			6 V		24	31		46		38	
$t_{\text{en}}$	$\overline{\text{OC}}$	Any	2 V		77	150		225		190	ns
			4.5 V		26	30		45		38	
			6 V		23	26		38		32	
$t_{\text{dis}}$	$\overline{\text{OC}}$	Any	2 V		52	150		225		190	ns
			4.5 V		24	30		45		38	
			6 V		22	26		38		32	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC574		SN74HC574		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	6			4		5		MHz
			4.5 V	30			20		24		
			6 V	36			24		28		
$t_{\text{pd}}$	CLK	Any	2 V		105	265		400		330	ns
			4.5 V		36	53		80		66	
			6 V		31	46		68		57	
$t_{\text{en}}$	$\overline{\text{OC}}$	Any	2 V		95	235		355		295	ns
			4.5 V		32	47		71		59	
			6 V		28	41		60		51	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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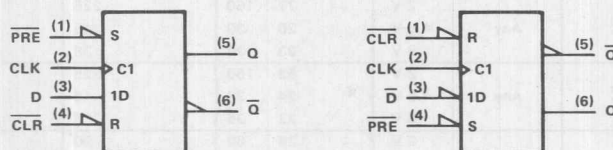
HCMOS DEVICES

# **TYPES SN54HC574, SN74HC574** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names (PRE and CLR) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

- Inputs Are TTL-Voltage Compatible
- High-Current 3-State Noninverting Outputs Drive Bus-Lines Directly or up to 15 LSTTL Loads
- Bus-Structured Pinout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These 8-bit registers feature three-state outputs designed specifically for bus driving. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight edge-triggered D-type flip-flops enter data on the low-to-high transition of the clock.

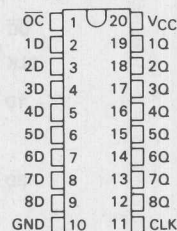
The output-control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HCT574 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT574 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

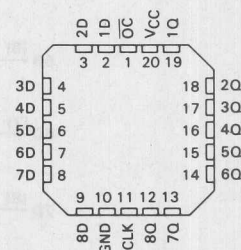
**FUNCTION TABLE  
(EACH FLIP-FLOP)**

INPUTS			OUTPUT
$\overline{\text{OC}}$	CLK	D	Q
L	$\uparrow$	H	H
L	$\uparrow$	L	L
L	L	X	$Q_0$
H	X	X	Z

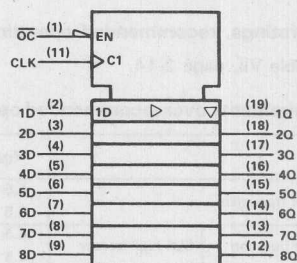
**SN54HCT574 ... J PACKAGE  
SN74HCT574 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HCT574 ... FH OR FK PACKAGE  
(TOP VIEW)**

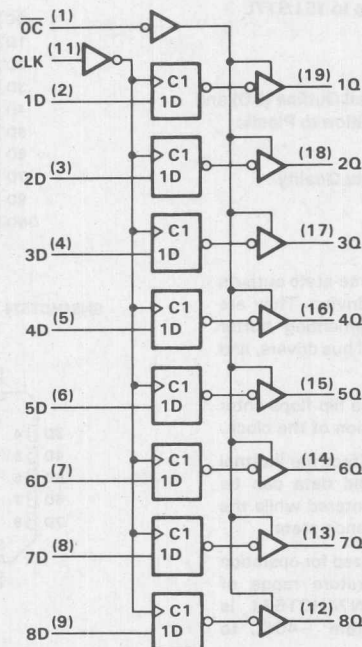


**logic symbol**



**TYPES SN54HCT574, SN74HCT574**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>		T <sub>A</sub> = 25°C		SN54HCT574		SN74HCT574		UNIT
					MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		4.5 V		0	30	0	20	0	24	MHz
			5.5 V		0	33	0	22	0	27	
t <sub>w</sub>	Pulse duration	CLK high or low	4.5 V		16		24		20		ns
			5.5 V		14		22		18		
t <sub>su</sub>	Setup time, data before CLK †		4.5 V		20		30		25		ns
			5.5 V		17		27		23		
t <sub>h</sub>	Hold time, data after CLK †		4.5 V		5		5		5		ns
			5.5 V		5		5		5		

# **TYPES SN54HCT574, SN74HCT574** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT574		SN74HCT574		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			4.5 V 5.5 V	30 33	36 40		20 22		24 27		MHz
t <sub>pd</sub>	CLK	Any	4.5 V 5.5 V		30 25	36 32		54 48		45 41	ns
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V 5.5 V		26 23	30 27		45 41		38 34	ns
t <sub>dis</sub>	$\overline{OC}$	Any	4.5 V 5.5 V		23 22	30 27		45 41		38 34	ns
t <sub>t</sub>		Any	4.5 V 5.5 V		10 9	12 11		18 16		15 14	ns

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	93 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted)  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT574		SN74HCT574		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			4.5 V 5.5 V	30 33	36 40		20 22		24 27		MHz
t <sub>pd</sub>	CLK	Any	4.5 V 5.5 V		40 35	53 47		80 71		66 60	ns
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V 5.5 V		34 29	47 39		71 94		59 78	ns
t <sub>t</sub>		Any	4.5 V 5.5 V		18 16	42 38		63 57		53 48	ns

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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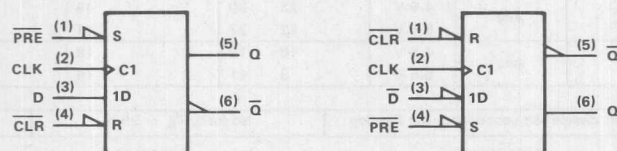
HCMOS DEVICES

## TYPES SN54HCT574, SN74HCT574 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

### D flip-flop signal conventions

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC604, SN74HC604 OCTAL 2-INPUT MULTIPLEXED LATCHES WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- 16 D-Type Registers, One for Each Data Input
- Multiplexer Selects Stored Data from Either A Bus or B Bus
- Application-Oriented for Maximum Speed
- Package Options Include Both Plastic and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC604 multiplexed latch is ideal for storing data from two input buses, A and B, and for providing the output bus with stored data from either the A or B register.

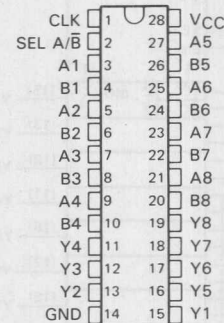
The clock loads data on the positive-going (low-level to high-level) transition. The clock pin also controls the active and high-impedance states of the outputs. When the clock pin is low, the outputs are in the high-impedance or off state. When the clock pin is high, the outputs are enabled.

The device is optimized for high-speed operation.

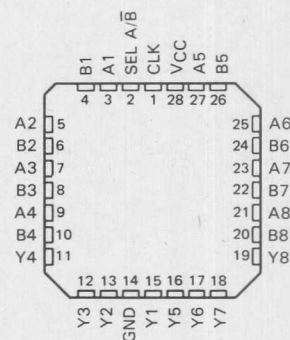
These functions are ideal for interfacing from a 16-bit microprocessor to a 64K RAM board. The row and column addresses can be loaded as one word from the microprocessor and then multiplexed sequentially to the RAM during the time that RAS and CAS are active.

The SN54HC604 is characterized for operation over the full military range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC604 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC604 ... J PACKAGE  
SN74HC604 ... J OR N PACKAGE  
(TOP VIEW)



SN54HC604 ... FH OR FK PACKAGE  
SN74HC604 ... FN PACKAGE  
(TOP VIEW)

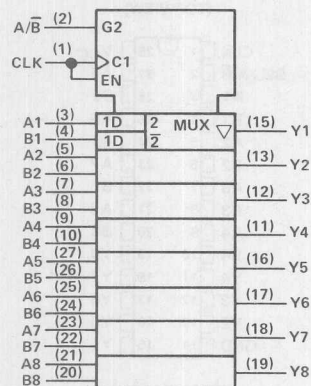


FUNCTION TABLE

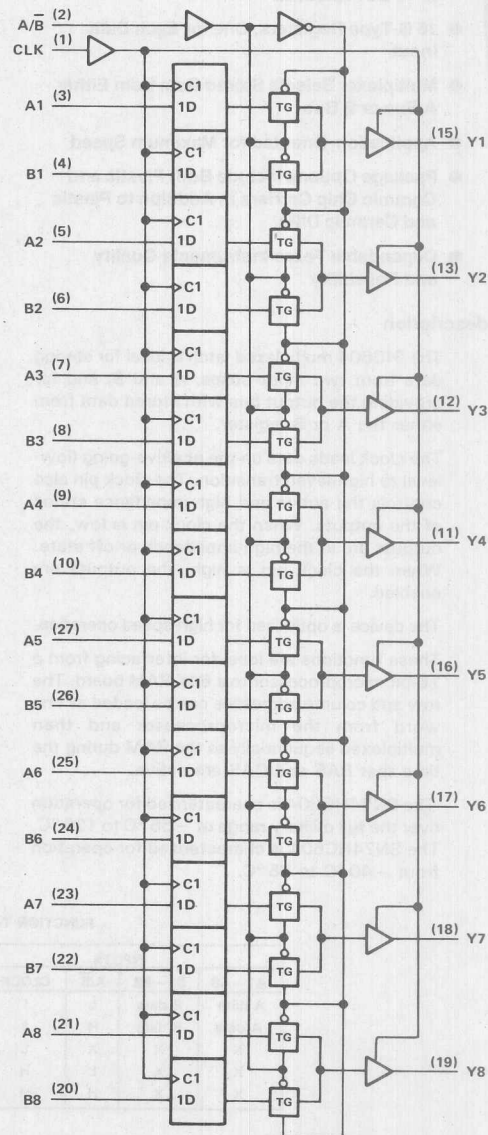
INPUTS				OUTPUTS Y1—Y8
A1—A8	B1—B8	A/B	CLOCK	
A data	B data	L	↑	B data
A data	B data	H	↑	A data
X	X	X	L	Z
X	X	X	H	B register stored data
X	X	H	H	A register stored data

**TYPES SN54HC604, SN74HC604**  
**OCTAL 2-INPUT MULTIPLEXED LATCHES WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



3

HCMOS DEVICES

# TYPES SN54HC604, SN74HC604 OCTAL 2-INPUT MULTIPLEXED LATCHES WITH 3-STATE OUTPUTS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC604		SN74HC604		UNIT
		MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	2 V	0		5	0	3.3	0	4	MHz
	4.5 V	0		25	0	17	0	20	
	6 V	0		29	0	20	0	24	
t <sub>w</sub> Pulse duration, CLK high or low	2 V	100			150		125		ns
	4.5 V	20			30		25		
	6 V	17			25		21		
t <sub>su</sub> Setup time, data before CLK†	2 V	75			115		95		ns
	4.5 V	15			23		19		
	6 V	13			20		16		
t <sub>h</sub> Hold time, data after CLK†	2 V	5			5		5		ns
	4.5 V	5			5		5		
	6 V	5			5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC604		SN74HC604		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5			3.3		4		MHz
			4.5 V	25			17		20		
			6 V	29			20		24		
t <sub>pd</sub>	A/B	Y	2 V		92	170		255		215	ns
			4.5 V		23	34		51		43	
			6 V		17	29		43		37	
t <sub>en</sub>	CLK	Y	2 V		96	195		295		245	ns
			4.5 V		25	39		59		49	
			6 V		19	33		50		42	
t <sub>dis</sub>	CLK	Y	2 V		84	200		300		250	ns
			4.5 V		30	40		60		50	
			6 V		26	34		51		43	
t <sub>t</sub>		Any	2 V		20	60				90	ns
			4.5 V		8	12				15	
			6 V		6	10				13	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	100 pF typ
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NOTE 1: For load circuits and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HC604, SN74HC604** **OCTAL 2-INPUT MULTIPLEXED LATCHES WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC604		SN74HC604		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A/ $\bar{B}$	Y	2 V		110	255		385		320	ns
			4.5 V		28	51		77		64	
			6 V		21	44		65		56	
t <sub>en</sub>	CLK	Y	2 V		120	280		425		350	ns
			4.5 V		30	56		85		70	
			6 V		23	48		72		61	
t <sub>t</sub>		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC620, SN54HC623, SN74HC620, SN74HC623 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Lock Bus-Latch Capability
- Choice of True or Inverting Logic
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

DEVICE	LOGIC
'HC620	Inverting
'HC623	True

### description

These octal bus transceivers are designed for asynchronous two-way communication between data buses. The control function implementation allows for maximum flexibility in timing.

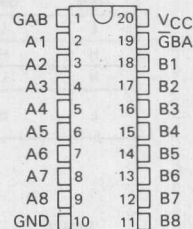
These devices allow data transmission from the A bus to the B bus or from the B bus to the A bus depending upon the logic levels at the enable inputs ( $\overline{\text{GBA}}$  and GAB).

The enable inputs can be used to disable the device so that the buses are effectively isolated.

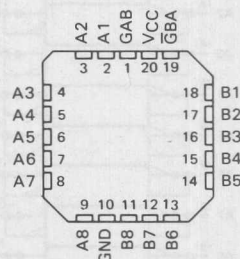
The dual-enable configuration gives these devices the capability to store data by simultaneous enabling of  $\overline{\text{GBA}}$  and GAB. Each output reinforces its input in this transceiver configuration. Thus when both control inputs are enabled and all other data sources to the two sets of bus lines are at high impedance, both sets of bus lines (16 in all) will remain at their last states. The 8-bit codes appearing on the two sets of buses will be identical for the 'HC623 or complementary for the 'HC620.

The SN54HC620 and SN54HC623 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC620 and SN74HC623 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC'... J PACKAGE  
SN74HC'... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC'... FH OR FK PACKAGE  
(TOP VIEW)



3

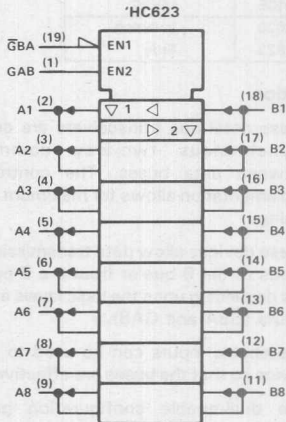
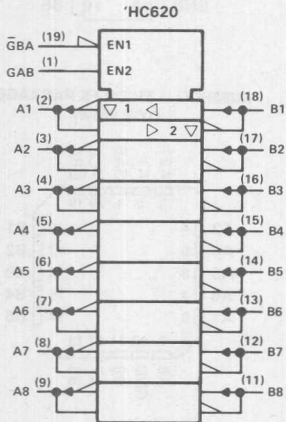
HCMOS DEVICES

**TYPES SN54HC620, SN54HC623, SN74HC620, SN74HC623**  
**OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

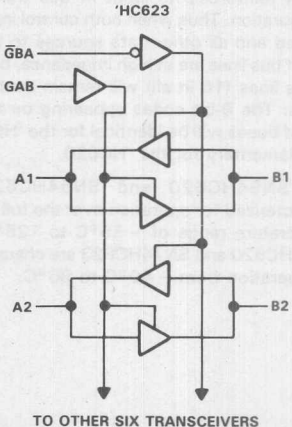
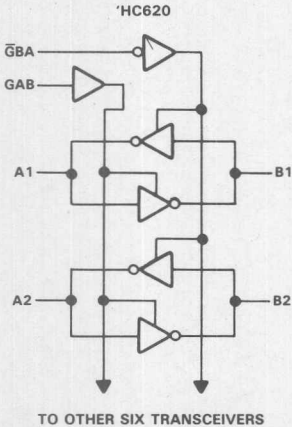
FUNCTION TABLE

ENABLE INPUTS		OPERATION	
$\overline{\text{GBA}}$	GAB	'HC620	'HC623
L	L	$\overline{\text{B}}$ data to A bus	B data to A bus
H	H	$\overline{\text{A}}$ data to B bus	A data to B bus
H	L	Isolation	Isolation
L	H	$\overline{\text{B}}$ data to A bus, $\overline{\text{A}}$ data to B bus	B data to A bus, A data to B bus

logic symbols



logic diagrams (positive logic)



3

HCMOS DEVICES



# **TYPES SN54HC620, SN54HC623, SN74HC620, SN74HC623** **OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC620 SN54HC623		SN74HC620 SN74HC623		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		29	105		160		130	ns
			4.5 V		10	21		32		26	
			6 V		8	18		27		22	
$t_{en}$	$\overline{\text{GBA}}$	A	2 V		112	210		315		265	ns
			4.5 V		27	42		63		53	
			6 V		20	36		54		45	
$t_{dis}$	$\overline{\text{GBA}}$	A	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		16	26		38		32	
$t_{en}$	GAB	B	2 V		112	210		315		265	ns
			4.5 V		27	42		63		53	
			6 V		20	36		54		45	
$t_{dis}$	GAB	B	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		16	26		38		32	
$t_t$		A or B	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC620 SN54HC623		SN74HC620 SN74HC623		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		44	135		200		170	ns
			4.5 V		14	27		40		34	
			6 V		11	23		34		29	
$t_{en}$	$\overline{\text{GBA}}$	A	2 V		130	270		405		335	ns
			4.5 V		31	54		81		67	
			6 V		23	46		69		56	
$t_{en}$	GAB	B	2 V		130	270		405		335	ns
			4.5 V		31	54		81		67	
			6 V		23	46		69		56	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# TYPE SHARON ENGINEERED DEVICES OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

Maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 3-3

Switching characteristics over recommended operating conditions are given in Table I. Values are for  $C_L = 50$  pF, and  $V_{DD} = 5.0$  V, and  $V_{SS} = 0$  V, unless otherwise noted.

PARAMETER	SYMBOL	UNIT	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.
Supply Current	$I_{DD}$	mA	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Input Current	$I_{II}$	mA	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2
Output Current	$I_{OZ}$	mA	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Propagation Delay	$t_{PD}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Setup Time	$t_{SU}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Hold Time	$t_{H}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Power Dissipation	$P_D$	mW	100	0	200	100	0	200	100	0	200	100	0	200	100	0	200	100	0	200

Notes: 1. For full power dissipation, see Table I. 2. For full power dissipation, see Table I.

Switching characteristics over recommended operating conditions are given in Table I. Values are for  $C_L = 50$  pF, and  $V_{DD} = 5.0$  V, and  $V_{SS} = 0$  V, unless otherwise noted.

PARAMETER	SYMBOL	UNIT	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.	TYPICAL	MIN.	MAX.
Supply Current	$I_{DD}$	mA	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Input Current	$I_{II}$	mA	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2
Output Current	$I_{OZ}$	mA	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Propagation Delay	$t_{PD}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Setup Time	$t_{SU}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Hold Time	$t_{H}$	ns	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20	10	0	20
Power Dissipation	$P_D$	mW	100	0	200	100	0	200	100	0	200	100	0	200	100	0	200	100	0	200

Notes: 1. For full power dissipation, see Table I. 2. For full power dissipation, see Table I.

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC640, SN54HC643, SN54HC645 SN74HC640, SN74HC643, SN74HC645 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Choice of True or Inverting Logic
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

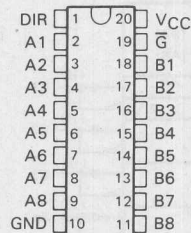
DEVICE	LOGIC
'HC640	Inverting
'HC643	True and Inverting
'HC645	True

### description

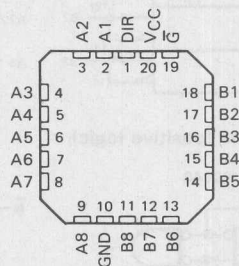
These octal bus transceivers are designed for asynchronous two-way communication between data buses. The devices transmit data from the A bus to the B bus or from the B bus to the A bus depending upon the level at the direction control (DIR) input. The enable input ( $\bar{G}$ ) can be used to disable the device so the buses are effectively isolated.

The SN54HC640, SN54HC643, and SN54HC645 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC640, SN74HC643, and SN74HC645 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC' . . . J PACKAGE  
SN74HC' . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC' . . . FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE

CONTROL INPUTS		OPERATION		
		'HC640	'HC645	'HC643
$\bar{G}$	DIR			
L	L	$\bar{B}$ data to A bus	B data to A bus	B data to A bus
L	H	$\bar{A}$ data to B bus	A data to B bus	$\bar{A}$ data to B bus
H	X	Isolation	Isolation	Isolation

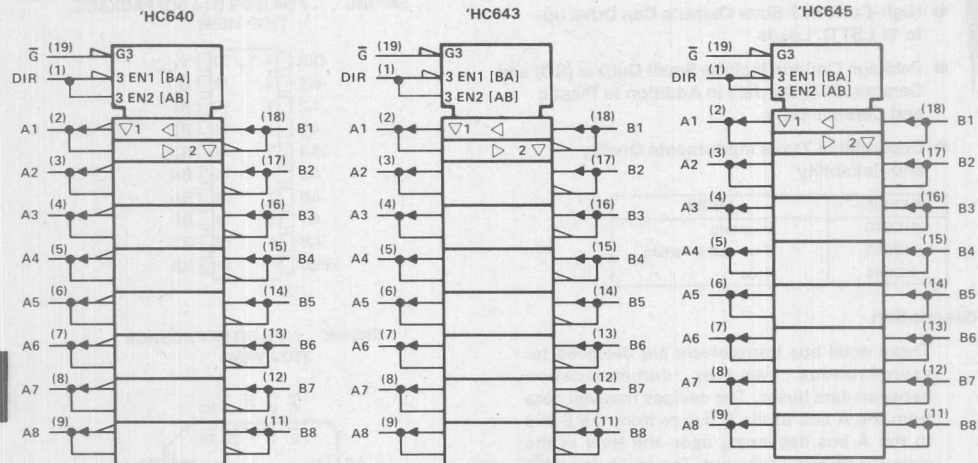
3

HCMOS DEVICES

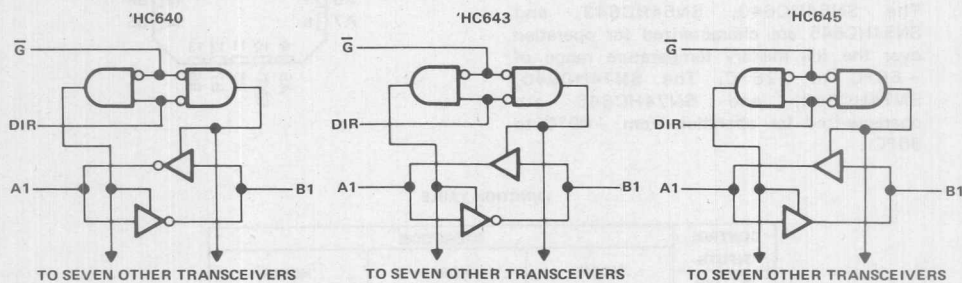
# TYPES SN54HC640, SN54HC643, SN54HC645

3

HCMOS DEVICES



logic diagrams (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

# **TYPES SN54HC640, SN74HC640** **OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

**'HC640 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC640		SN74HC640		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A'	2 V		29	105		160		130	ns
			4.5 V		10	21		32		26	
			6 V		8	18		27		22	
$t_{en}$	$\overline{G}$	A or B	2 V		109	230		340		290	ns
			4.5 V		27	46		68		58	
			6 V		20	39		58		49	
$t_{dis}$	$\overline{G}$	A or B	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		16	26		38		32	
$t_t$		A or B	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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**'HC640 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC640		SN74HC640		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		44	190		290		235	ns
			4.5 V		14	38		58		47	
			6 V		11	33		49		41	
$t_{en}$	$\overline{G}$	A or B	2 V		124	315		470		395	ns
			4.5 V		31	63		94		79	
			6 V		23	54		88		68	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# TYPES SN54HC643, SN74HC643 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

'HC643 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC643		SN74HC643		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		29	110		165		140	ns
			4.5 V		10	22		33		28	
			6 V		8	19		28		24	
$t_{en}$	$\overline{G}$	A or B	2 V		109	230		340		290	ns
			4.5 V		27	46		68		58	
			6 V		20	39		58		49	
$t_{dis}$	$\overline{G}$	A or B	2 V		40	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		16	26		38		32	
$t_t$		A or B	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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'HC643 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC643		SN74HC643		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		44	195		295		245	ns
			4.5 V		14	39		59		49	
			6 V		11	34		50		43	
$t_{en}$	$\overline{G}$	A or B	2 V		124	315		470		395	ns
			4.5 V		31	63		94		79	
			6 V		23	54		80		68	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# TYPES SN54HC645, SN74HC645 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

'HC645 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC645		SN74HC645		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		40	105		160		130	ns
			4.5 V		15	21		32		26	
			6 V		12	18		27		22	
$t_{en}$	$\bar{G}$	A or B	2 V		125	230		340		290	ns
			4.5 V		23	46		68		58	
			6 V		20	39		58		49	
$t_{dis}$	$\bar{G}$	A or B	2 V		74	200		300		250	ns
			4.5 V		25	40		60		50	
			6 V		21	34		51		43	
$t_t$		A or B	2 V		20	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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'HC645 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC645		SN74HC645		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		54	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		15	26		38		33	
$t_{en}$	$\bar{G}$	A or B	2 V		150	315		470		395	ns
			4.5 V		31	63		94		79	
			6 V		25	54		80		68	
$t_t$		A or B	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

## 3

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT640, SN54HCT643, SN54HCT645 SN74HCT640, SN74HCT643, SN74HCT645 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- Choice of True or Inverting Logic
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

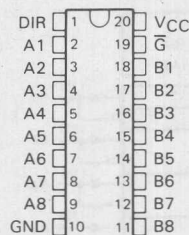
DEVICE	LOGIC
'HCT640	Inverting
'HCT643	True and Inverting
'HCT645	True

### description

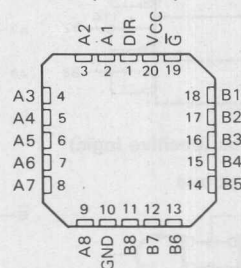
These octal bus transceivers are designed for asynchronous two-way communication between data buses. The devices transmit data from the A bus to the B bus or from the B bus to the A bus depending upon the level at the direction control (DIR) input. The enable input ( $\overline{G}$ ) can be used to disable the device so the buses are effectively isolated.

The SN54HCT640, SN54HCT643, and SN54HCT645 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT640, SN74HCT643 and SN74HCT645 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT'...J PACKAGE  
SN74HCT'...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT'...FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE

CONTROL INPUTS		OPERATION		
		'HCT640	'HCT645	'HCT643
$\overline{G}$	DIR			
L	L	$\overline{B}$ data to A bus	B data to A bus	B data to A bus
L	H	$\overline{A}$ data to B bus	A data to B bus	$\overline{A}$ data to B bus
H	X	Isolation	Isolation	Isolation

### ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

TEXAS  
INSTRUMENTS

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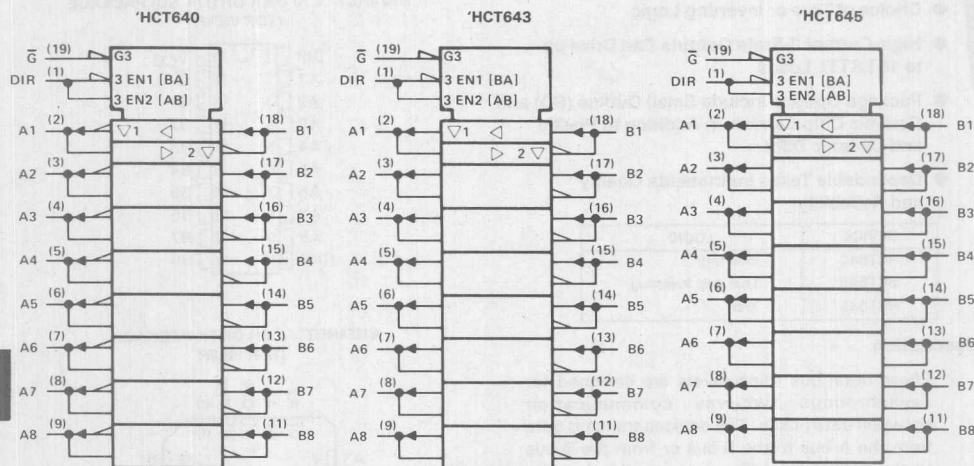
3-325

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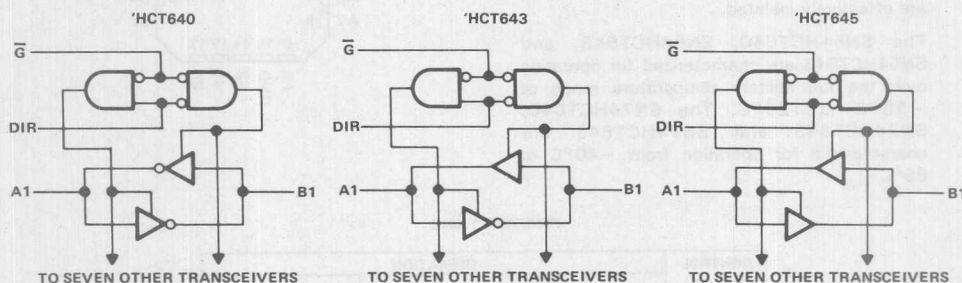
CMOS DEVICES

**TYPES SN54HCT640, SN54HCT643, SN54HCT645  
SN74HCT640, SN74HCT643, SN74HCT645  
OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

**logic symbols**



**logic diagrams (positive logic)**



**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table VII, page 2-14.

**TYPES SN54HCT640, SN54HCT643  
SN74HCT640, SN74HCT643  
OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

'HCT640, 'HCT643 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT640 SN54HCT643		SN74HCT640 SN74HCT643		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		14	21		32		26	ns
			5.5 V		12	18		27		23	
$t_{en}$	$\overline{G}$	A or B	4.5 V		27	35		53		44	ns
			5.5 V		24	32		47		39	
$t_{dis}$	$\overline{G}$	A or B	4.5 V		20	30		45		38	ns
			5.5 V		18	26		41		34	
$t_t$		A or B	4.5 V		9	12		18		15	ns
			5.5 V		8	11		16		14	

$C_{pd}$	Power dissipation capacitance per transceiver	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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'HCT640, 'HCT643 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT640 SN54HCT643		SN74HCT640 SN74HCT643		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		17	27		41		34	ns
			5.5 V		15	24		37		30	
$t_{en}$	$\overline{G}$	A or B	4.5 V		31	45		68		56	ns
			5.5 V		28	41		61		51	
$t_t$		A or B	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# **TYPES SN54HCT645, SN74HCT645** **OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

'HCT645 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT645		SN74HCT645		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		16	22		33		28	ns
			5.5 V		14	20		30		25	
t <sub>en</sub>	$\overline{G}$	A or B	4.5 V		25	46		69		58	ns
			5.5 V		22	41		62		52	
t <sub>dis</sub>	$\overline{G}$	A or B	4.5 V		26	40		60		50	ns
			5.5 V		23	36		54		45	
t <sub>t</sub>		A or B	4.5 V		9	12		18		15	ns
			5.5 V		8	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per transceiver	No load, T <sub>A</sub> = 25°C	40 pF typ
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'HCT645 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT645		SN74HCT645		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		20	30		45		38	ns
			5.5 V		18	27		41		34	
t <sub>en</sub>	$\overline{G}$	A or B	4.5 V		36	59		89		74	ns
			5.5 V		30	63		80		67	
t <sub>t</sub>		A or B	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648 OCTAL BUS TRANSCIVERS AND REGISTERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Independent Registers for A and B Buses
- Multiplexed Real-Time and Stored Data
- Choice of True or Inverting Data Paths
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

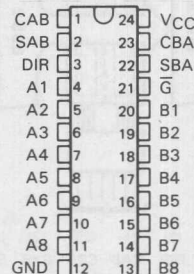
These devices consist of bus transceiver circuits with 3-state outputs, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the input bus or from the internal registers. Data on the A or B bus will be clocked into the registers on the low-to-high transition of the appropriate clock pin (CAB or CBA). The examples on the following page demonstrate the four fundamental bus-management functions that can be performed with the 'HC646 or 'HC648.

Enable ( $\bar{G}$ ) and direction (DIR) pins are provided to control the transceiver functions. In the transceiver mode, data present at the high-impedance port may be stored in either register or in both. The select controls (SAB and SBA) can multiplex stored and real-time (transparent mode) data. The direction control determines which bus will receive data when enable  $\bar{G}$  is active (low). In the isolation mode (enable  $\bar{G}$  high), A data may be stored in one register and/or B data may be stored in the other register.

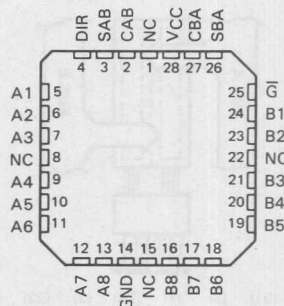
When an output function is disabled, the input function is still enabled and may be used to store and transmit data. Only one of the two buses, A or B, may be driven at a time.

The SN54HC' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC' ... JT PACKAGE  
SN74HC' ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC' ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

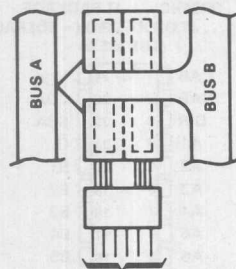
3

HCMOS DEVICES

**TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

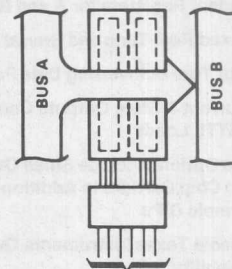
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HCMOS DEVICES



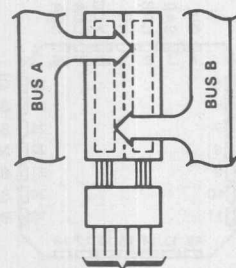
(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	L	X	X	X	L

**REAL-TIME TRANSFER**  
**BUS B TO BUS A**



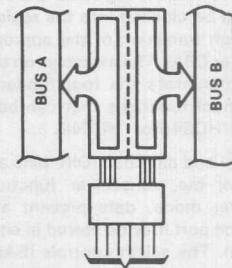
(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	H	X	X	L	X

**REAL-TIME TRANSFER**  
**BUS A TO BUS B**



(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
X	X	↑	X	X	X
X	X	X	↑	X	X
H	X	↑	↑	X	X

**STORAGE FROM**  
**A, B, OR A AND B**



(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	L	X	H or L	X	H
L	H	H or L	X	H	X

**TRANSFER STORED DATA**  
**TO A OR B**

Pin numbers shown are for JT and NT packages.

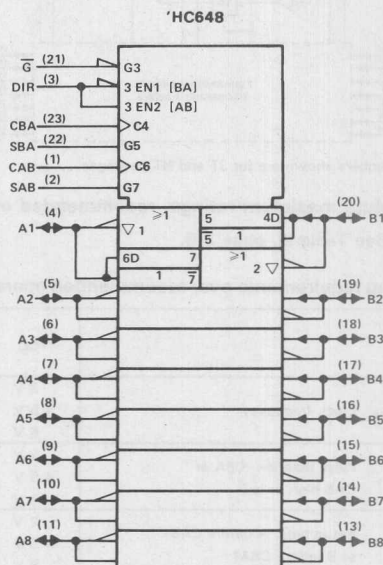
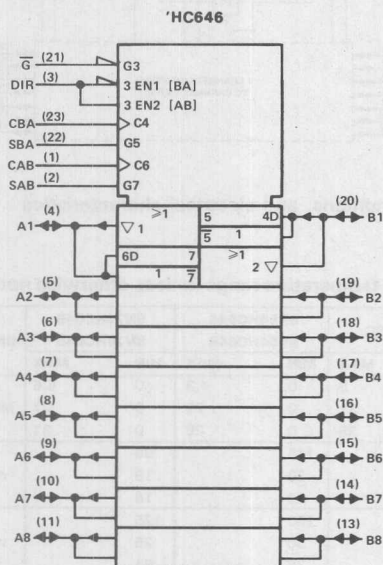
# **TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

**FUNCTION TABLE**

INPUTS						DATA I/O†		OPERATION OR FUNCTION	
$\bar{G}$	DIR	CAB	CBA	SAB	SBA	A1 THRU A8	B1 THRU B8	'HC646	'HC648
X	X	↑	X	X	X	Input	Not specified	Store A, B unspecified	Store A, B unspecified
X	X	X	↑	X	X	Not specified	Input	Store B, A unspecified	Store B, A unspecified
H	X	↑	↑	X	X			Store A and B Data	Store A and B Data
H	X	H or L	H or L	X	X	Input	Input	Isolation, hold storage	Isolation, hold storage
L	L	X	X	X	L			Real-Time B Data to A Bus	Real-Time $\bar{B}$ Data to A Bus
L	L	X	H or L	X	H	Output	Input	Stored B Data to A Bus	Stored $\bar{B}$ Data to A Bus
L	H	X	X	L	X			Real-Time A Data to B Bus	Real-Time A Data to B Bus
L	H	H or L	X	H	X	Input	Output	Stored A Data to B Bus	Stored $\bar{A}$ Data to B Bus

† The data output functions may be enabled or disabled by various signals at the  $\bar{G}$  and DIR inputs. Data input functions are always enabled, i.e., data at the bus pins will be stored on every low-to-high transition on the clock inputs.

## **logic symbols**



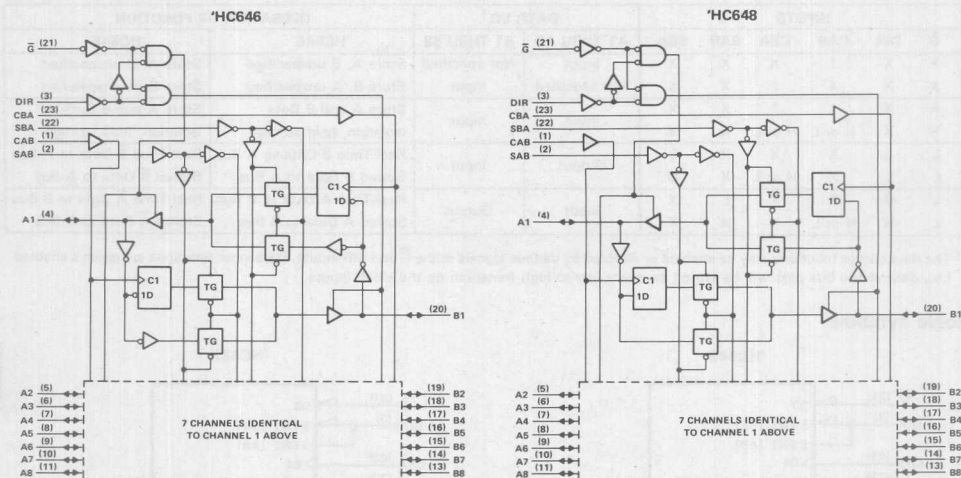
Pin numbers shown are for JT and NT packages.

**3**

**HCMOS DEVICES**

# **TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	$V_{CC}$	$T_A = 25^\circ C$		SN54HC646 SN54HC648		SN74HC646 SN74HC648		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
$f_{clock}$ Clock frequency	2 V	0	6	0	4.3	0	5.5	MHz
	4.5 V	0	31	0	22	0	27	
	6 V	0	36	0	25	0	31	
$t_w$ Pulse duration, CBA or CAB high or low	2 V	80		115		95		ns
	4.5 V	16		23		19		
	6 V	14		20		16		
$t_{su}$ Setup time, A before CAB† or B before CBA†	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
$t_h$ Hold time, A after CAB† or B after CBA†	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

**TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC646 SN54HC648		SN74HC646 SN74HC648		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$			2 V	6	11		4.4		5.5		MHz
			4.5 V	31	54		22		27		
			6 V	36	64		25		31		
$t_{pd}$	CBA or CAB	A or B	2 V		65	180		270		225	ns
			4.5 V		18	36		54		45	
			6 V		14	31		46		38	
$t_{pd}$	A or B	B or A	2 V		50	135		205		170	ns
			4.5 V		14	27		41		34	
			6 V		11	23		35		29	
$t_{pd}$	SBA or SAB <sup>†</sup>	A or B	2 V		70	190		285		240	ns
			4.5 V		20	38		57		48	
			6 V		16	32		48		41	
$t_{en}$	$\bar{G}$	A or B	2 V		85	245		370		305	ns
			4.5 V		25	49		74		61	
			6 V		20	42		63		52	
$t_{dis}$	$\bar{G}$	A or B	2 V		85	245		370		305	ns
			4.5 V		25	49		74		61	
			6 V		20	42		63		52	
$t_{en}$	DIR	A or B	2 V		80	245		370		305	ns
			4.5 V		25	49		74		61	
			6 V		20	42		63		52	
$t_{dis}$	DIR	A or B	2 V		80	245		370		305	ns
			4.5 V		25	49		74		61	
			6 V		20	42		63		52	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

<sup>†</sup>These parameters are measured with the internal output state of the storage register opposite to that of the bus input.

3

HCMOS DEVICES

**TYPES SN54HC646, SN54HC648, SN74HC646, SN74HC648**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC646 SN54HC648		SN74HC648 SN74HC648		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CBA or CAB	A or B	2 V		90	265		400		330	ns
			4.5 V		24	53		80		66	
			6 V		20	46		68		57	
$t_{pd}$	A or B	B or A	2 V		70	220		335		280	ns
			4.5 V		20	44		67		56	
			6 V		15	38		57		49	
$t_{pd}$	SBA or SAB <sup>†</sup>	A or B	2 V		80	275		415		345	ns
			4.5 V		24	55		83		69	
			6 V		20	47		70		60	
$t_{en}$	$\overline{G}$	A or B	2 V		113	330		500		410	ns
			4.5 V		33	66		100		82	
			6 V		27	57		85		71	
$t_{en}$	DIR	A or B	2 V		113	330		500		410	ns
			4.5 V		33	66		100		82	
			6 V		27	57		85		71	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		43	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

<sup>†</sup> These parameters are measured with the internal output state of the storage register opposite to that of the bus input.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT646, SN54HCT648, SN74HCT646, SN74HCT648 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- Independent Registers for A and B Buses
- Multiplexed Real-Time and Stored Data
- Choice of True or Inverting Data Paths
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

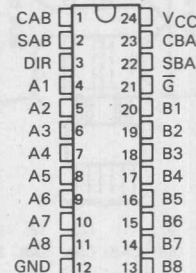
These devices consist of bus transceiver circuits with 3-state outputs, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the input bus or from the internal registers. Data on the A or B bus will be clocked into the registers on the low-to-high transition of the appropriate clock pin (CAB or CBA). The examples on the following page demonstrate the four fundamental bus-management functions that can be performed with the 'HCT646 or 'HCT648.

Enable ( $\bar{G}$ ) and direction (DIR) pins are provided to control the transceiver functions. In the transceiver mode, data present at the high-impedance port may be stored in either register or in both. The select controls (SAB and SBA) can multiplex stored and real-time (transparent mode) data. The direction control determines which bus will receive data when enable  $\bar{G}$  is active (low). In the isolation mode (enable  $\bar{G}$  high), A data may be stored in one register and/or B data may be stored in the other register.

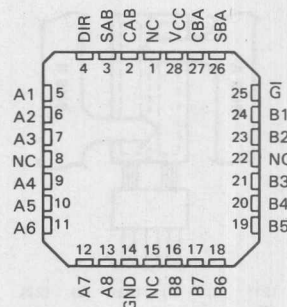
When an output function is disabled, the input function is still enabled and may be used to store and transmit data. Only one of the two buses, A or B, may be driven at a time.

The SN54HCT' family is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT' family is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT' ... JT PACKAGE  
SN74HCT' ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT' ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

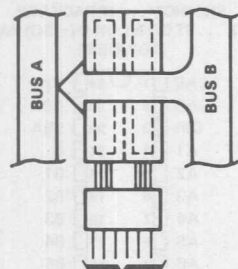
3

HCMOS DEVICES

**TYPES SN54HCT646, SN54HCT648, SN74HCT646, SN74HCT648**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

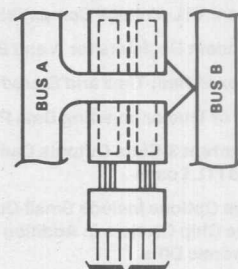
**3**

**HCMOS DEVICES**



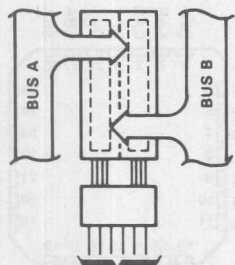
(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	L	X	X	X	L

**REAL-TIME TRANSFER**  
**BUS B TO BUS A**



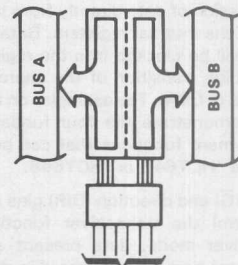
(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	H	X	X	L	X

**REAL-TIME TRANSFER**  
**BUS A TO BUS B**



(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
X	X	↑	X	X	X
X	X	X	↑	X	X
H	X	↑	↑	X	X

**STORAGE FROM**  
**A, B, OR A AND B**



(21)	(3)	(1)	(23)	(2)	(22)
$\bar{G}$	DIR	CAB	CBA	SAB	SBA
L	L	X	H or L	X	H
L	H	H or L	X	H	X

**TRANSFER STORED DATA**  
**TO A OR B**

Pin numbers shown are for JT and NT packages.

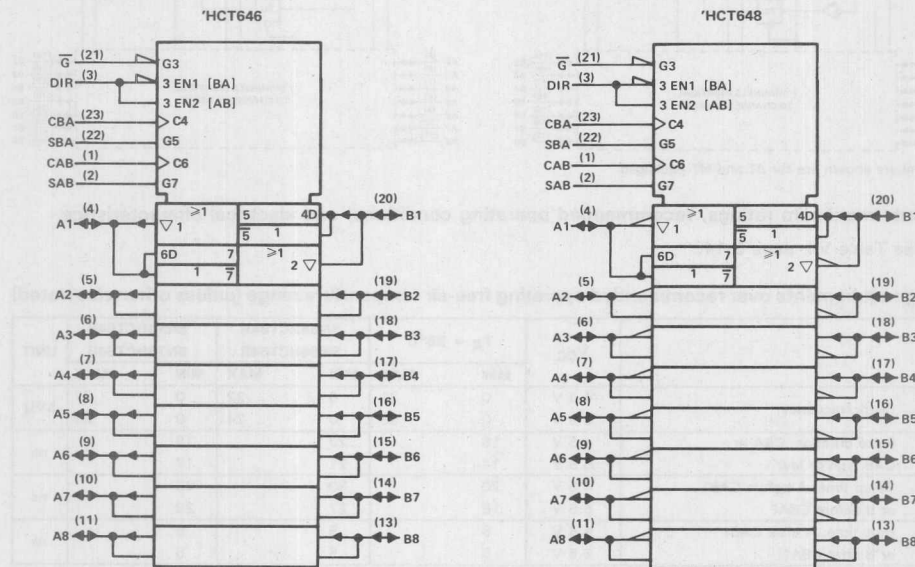
# TYPES SN54HCT646, SN54HCT648, SN74HCT646, SN74HCT648 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

FUNCTION TABLE

INPUTS						DATA I/O†		OPERATION OR FUNCTION	
$\bar{G}$	DIR	CAB	CBA	SAB	SBA	A1 THRU A8	B1 THRU B8	'HCT646	'HCT648
X	X	↑	X	X	X	Input	Not specified	Store A, B unspecified	Store A, B unspecified
X	X	X	↑	X	X	Not specified	Input	Store B, A unspecified	Store B, A unspecified
H	X	↑	↑	X	X			Store A and B Data	Store A and B Data
H	X	H or L	H or L	X	X	Input	Input	Isolation, hold storage	Isolation, hold storage
L	L	X	X	X	L	Output	Input	Real-Time B Data to A Bus	Real-Time $\bar{B}$ Data to A Bus
L	L	X	X	H or L	X			Stored B Data to A Bus	Stored $\bar{B}$ Data to A Bus
L	H	X	X	L	X	Input	Output	Real-Time A Data to B Bus	Real-Time $\bar{A}$ Data to B Bus
L	H	H or L	X	H	X			Stored A Data to B Bus	Stored $\bar{A}$ Data to B Bus

† The data output functions may be enabled or disabled by various signals at the  $\bar{G}$  and DIR inputs. Data input functions are always enabled, i.e., data at the bus pins will be stored on every low-to-high transition on the clock inputs.

## logic symbols



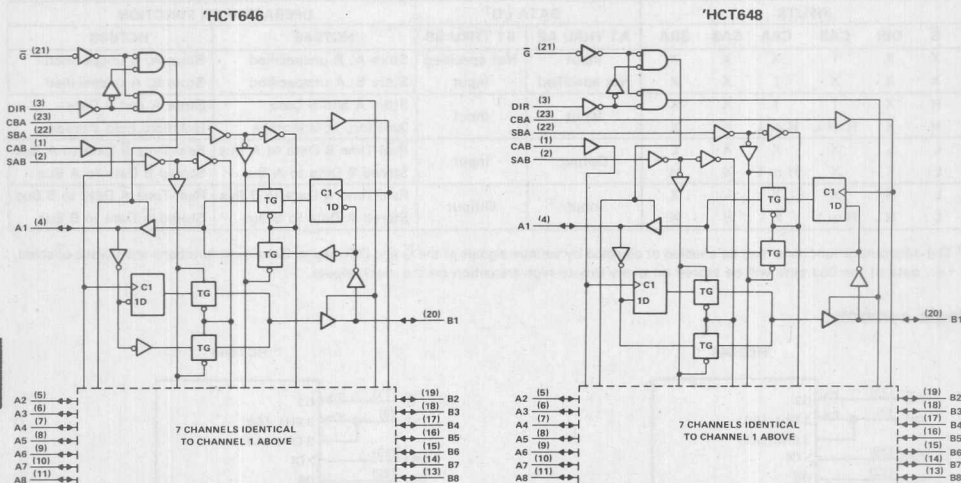
Pin numbers shown are for JT and NT packages.

3

HCMOS DEVICES

# **TYPES SN54HCT646, SN54HCT648, SN74HCT646, SN74HCT648** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	VCC	TA = 25°C		SN54HCT646 SN54HCT648		SN74HCT646 SN74HCT648		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	4.5 V	0	31	0	22	0	27	MHz
	5.5 V	0	36	0	24	0	29	
t <sub>w</sub> Pulse duration, CBA or CAB high or low	4.5 V	16		23		19		ns
	5.5 V	14		21		17		
t <sub>su</sub> Setup time, A before CAB† or B before CBA†	4.5 V	20		30		25		ns
	5.5 V	18		27		23		
t <sub>h</sub> Hold time, A after CAB† or B after CBA†	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

**TYPES SN54HCT646, SN54HCT648, SN74HCT646, SN74HCT648**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT646 SN54HCT648		SN74HCT646 SN74HCT648		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			4.5 V	31	54		22		27		MHz
			5.5 V	36	64		24		29		
$t_{pd}$	CBA or CAB	A or B	4.5 V		18	36		54		45	ns
			5.5 V		16	32		49		41	
$t_{pd}$	A or B	B or A	4.5 V		14	27		41		34	ns
			5.5 V		12	24		37		31	
$t_{pd}$	SBA or SAB†	A or B	4.5 V		20	38		57		48	ns
			5.5 V		17	34		51		43	
$t_{en}$	$\overline{G}$	A or B	4.5 V		25	49		74		61	ns
			5.5 V		22	44		67		55	
$t_{dis}$	$\overline{G}$	A or B	4.5 V		25	49		74		61	ns
			5.5 V		22	44		67		55	
$t_{en}$	DIR	A or B	4.5 V		25	49		74		61	ns
			5.5 V		22	44		67		55	
$t_{dis}$	DIR	A or B	4.5 V		25	49		74		61	ns
			5.5 V		22	44		67		55	
$t_t$		Any	4.5 V		9	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT646 SN54HCT648		SN74HCT646 SN74HCT648		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CBA or CAB	A or B	4.5 V		24	53		80		66	ns
			5.5 V		22	47		52		60	
$t_{pd}$	A or B	B or A	4.5 V		22	44		67		55	ns
			5.5 V		20	39		60		50	
$t_{pd}$	SBA or SAB†	A or B	4.5 V		26	55		83		69	ns
			5.5 V		24	49		74		62	
$t_{en}$	$\overline{G}$	A or B	4.5 V		33	66		100		87	ns
			5.5 V		22	59		90		74	
$t_{en}$	DIR	A or B	4.5 V		33	66		100		87	ns
			5.5 V		22	59		90		74	
$t_t$		Any	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

† These parameters are measured with the internal output state of the storage register opposite to that of the bus input.

3

HCMOS DEVICES





## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC651, SN54HC652, SN74HC651, SN74HC652 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Bus Transceivers and Registers
- Independent Registers and Enables for A and B Buses
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Multiplexed Real-Time and Stored Data
- Choice of True and Inverting Data Paths
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

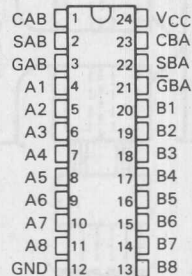
### description

These devices consist of bus transceiver circuits, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the data bus or from the internal storage registers. Enable GAB and  $\bar{G}BA$  are provided to control the transceiver functions. SAB and SBA control pins are provided to select whether real-time or stored data is transferred. A low input level selects real-time data, and a high selects stored data. The examples on the following page demonstrate the four fundamental bus-management functions that can be performed with the 'HC651 and 'HC652.

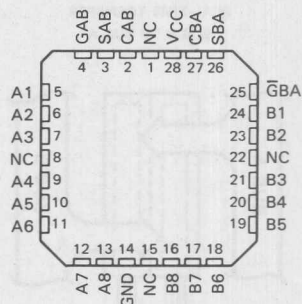
Data on the A or B data bus, or both, can be stored in the internal D flip-flops by low-to-high transitions at the appropriate clock pins (CAB or CBA) regardless of the select or enable control pins. When SAB and SBA are in the real-time transfer mode, it is also possible to store data without using the internal D-type flip-flops by simultaneously enabling GAB and  $\bar{G}BA$ . In this configuration each output reinforces its input. Thus, when all other data sources to the two sets of bus lines are at high impedance, each set of bus lines will remain at its last state.

The SN54HC651 and SN54HC652 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC651 and SN74HC652 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC651, SN54HC652... JT PACKAGE  
SN74HC651, SN74HC652... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC651, SN54HC652... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

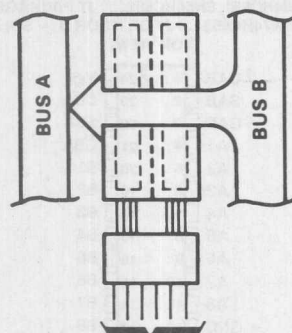
3

HCMOS DEVICES

**TYPES SN54HC651, SN54HC652, SN74HC651, SN74HC652**  
**OCTAL BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

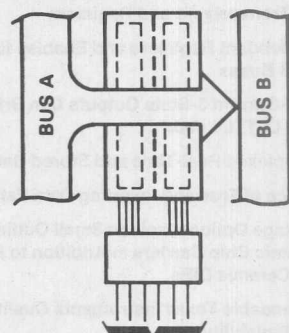
**3**

**HCMOS DEVICES**



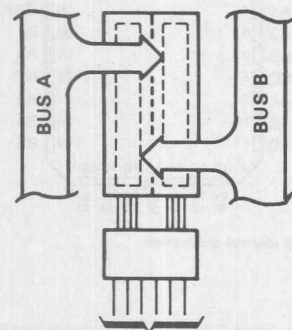
(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
L	L	X	X	X	L

**REAL-TIME TRANSFER**  
**BUS B TO BUS A**



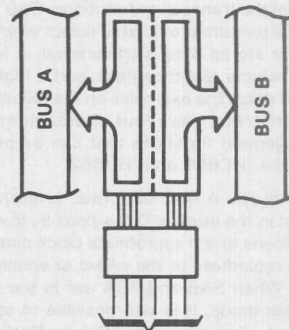
(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
H	H	X	X	L	X

**REAL-TIME TRANSFER**  
**BUS A TO BUS B**



(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
X	H	↑	X	X	X
L	X	X	↑	X	X
L	H	↑	↑	X	X

**STORAGE FROM**  
**A AND/OR B**



(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
H	L	H or L	H or L	H	H

**TRANSFER**  
**STORED DATA**  
**TO A AND/OR B**

Pin numbers shown are for JT and NT packages.

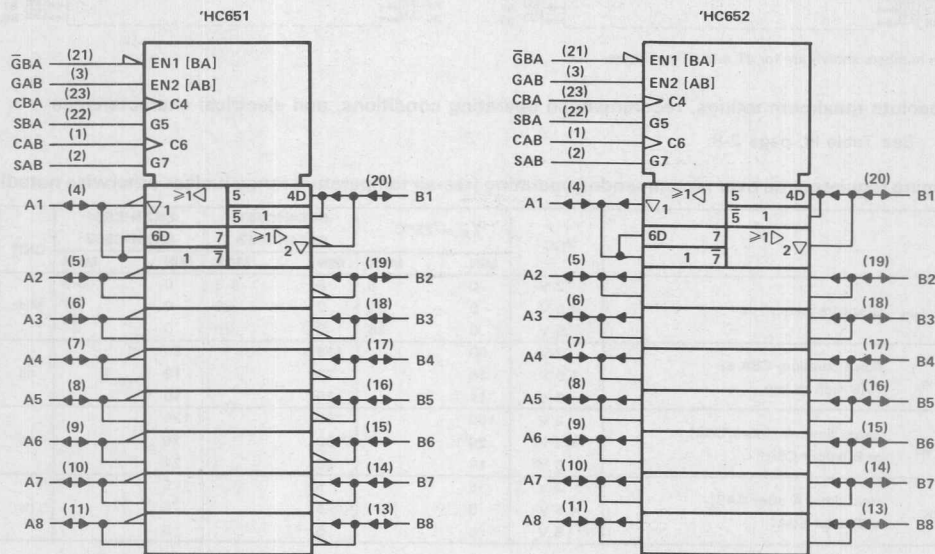
# **TYPES SN54HC651, SN54HC652, SN74HC651, SN74HC652** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

**FUNCTION TABLE**

INPUTS						DATA I/O†		OPERATION OR FUNCTION	
GAB	GBA	CAB	CBA	SAB	SBA	A1 THRU A8	B1 THRU B8	'HC651	'HC652
L	H	H or L	H or L	X	X	Input	Input	Isolation	Isolation
L	H	↑	↑	X	X			Store A and B Data	Store A and B Data
X	H	↑	H or L	X	X	Input	Not specified	Store A, Hold B	Store A, Hold B
H	H	↑	↑	X	X			Store A in both registers	Store A in both registers
L	X	H or L	↑	X	X	Not specified	Input	Hold A, Store B	Hold A, Store B
L	L	↑	↑	X	X			Store B in both registers	Store B in both registers
L	L	X	X	X	L	Output	Input	Real-Time $\bar{B}$ Data to A Bus	Real-Time B Data to A Bus
L	L	X	H or L	X	H			Stored $\bar{B}$ Data to A Bus	Stored B Data to A Bus
H	H	X	X	L	X	Input	Output	Real-Time $\bar{A}$ Data to B Bus	Real-Time A Data to B Bus
H	H	H or L	X	H	X			Stored $\bar{A}$ Data to B Bus	Stored A Data to B Bus
H	L	H or L	H or L	H	H	Output	Output	Stored $\bar{A}$ Data to B Bus and Stored $\bar{B}$ Data to A Bus	Stored A Data to B Bus and Stored B Data to A Bus

† The data output functions may be enabled or disabled by various signals at the GAB and  $\bar{G}BA$  inputs. Data input functions are always enabled, i.e., data at the bus pins will be stored on every low-to-high transition on the clock inputs.

## **logic symbols**



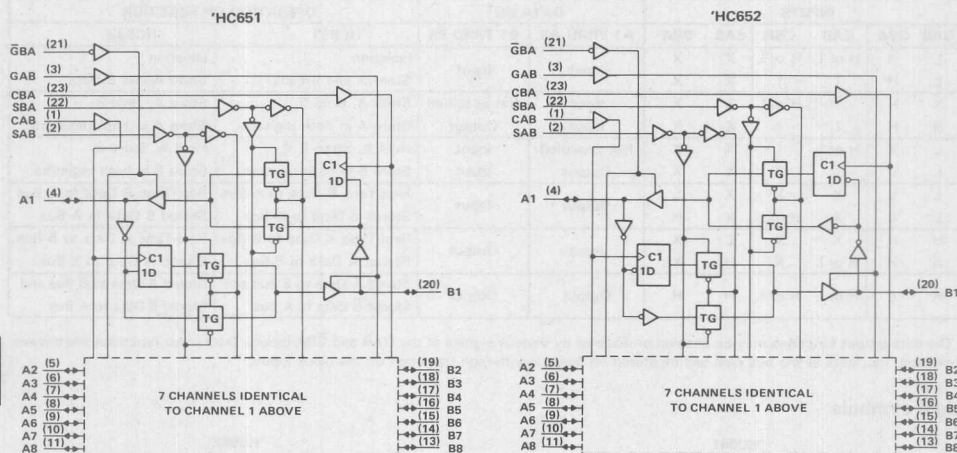
Pin numbers shown are for JT and NT packages.

**3**

**HCMOS DEVICES**

# **TYPES SN54HC651, SN54HC652, SN74HC651, SN74HC652** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## **absolute maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

## **timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

	$V_{CC}$	$T_A = 25^\circ\text{C}$		SN54HC651 SN54HC652		SN74HC651 SN74HC652		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
$f_{clock}$ Clock frequency	2 V	0	6	0	4.3	0	5.5	MHz
	4.5 V	0	31	0	22	0	27	
	6 V	0	36	0	25	0	31	
$t_w$ Pulse duration, CBA or CAB high or low	2 V	80		115		95		ns
	4.5 V	16		23		19		
	6 V	14		20		16		
$t_{su}$ Setup time, A before CAB† or B before CBA†	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
$t_h$ Hold time, A after CAB† or B after CBA†	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

3  
HCMOS DEVICES

# **TYPES SN54HC651, SN54HC652, SN74HC651, SN74HC652** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC651 SN54HC652		SN74HC652 SN74HC652		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$			2 V	6	10		4.3		5.5		MHz
			4.5 V	31	40		22		27		
			6 V	36	45		25		31		
$t_{pd}$	CBA or CAB	A or B	2 V		65	180		270		225	ns
			4.5 V		18	36		54		45	
			6 V		14	31		46		38	
$t_{pd}$	A or B	B or A	2 V		50	135		205		170	ns
			4.5 V		14	27		41		34	
			6 V		11	23		35		29	
$t_{pd}$	SBA or SAB <sup>†</sup>	A or B	2 V		70	190		285		240	ns
			4.5 V		20	38		57		48	
			6 V		16	32		48		41	
$t_{en}$	$\overline{G}BA$ or GAB	A or B	2 V		85	245		370		305	ns
			4.5 V		25	49		74		61	
			6 V		20	42		63		52	
$t_{dis}$	$\overline{G}BA$ or GAB	A or B	2 V		50	245		370		305	ns
			4.5 V		23	49		74		61	
			6 V		20	42		63		52	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC651 SN54HC652		SN74HC651 SN74HC652		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CBA or CAB	A or B	2 V		90	265		400		330	ns
			4.5 V		24	53		80		66	
			6 V		18	46		68		57	
$t_{pd}$	A or B	B or A	2 V		70	220		335		275	ns
			4.5 V		20	44		70		55	
			6 V		15	38		57		48	
$t_{pd}$	SBA or SAB <sup>†</sup>	A or B	2 V		80	275		415		345	ns
			4.5 V		24	55		83		69	
			6 V		20	47		70		60	
$t_{en}$	$\overline{G}BA$ or GAB	A or B	2 V		100	330		500		410	ns
			4.5 V		33	66		100		82	
			6 V		27	57		85		71	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		43	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

<sup>†</sup>These parameters are measured with the internal output state of the storage register opposite to that of the bus input.



## HCMOS DEVICES



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT651, SN54HCT652, SN74HCT651, SN74HCT652 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- Bus Transceivers and Registers
- Independent Registers and Enables for A and B Buses
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Multiplexed Real-Time and Stored Data
- Choice of True and Inverting Data Paths
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

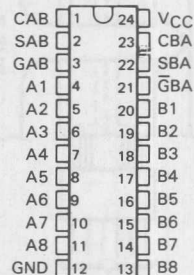
### description

These devices consist of bus transceiver circuits, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the data bus or from the internal storage registers. Enable GAB and  $\bar{G}BA$  are provided to control the transceiver functions. SAB and SBA control pins are provided to select whether real-time or stored data is transferred. A low input level selects real-time data, and a high selects stored data. The examples on the following page demonstrate the four fundamental bus-management functions that can be performed with the 'HCT651 and 'HCT652.

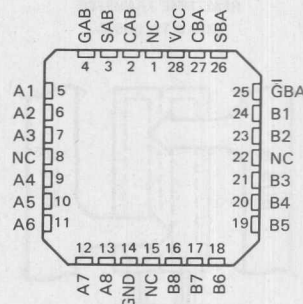
Data on the A or B data bus, or both, can be stored in the internal D flip-flops by low-to-high transitions at the appropriate clock pins (CAB or CBA) regardless of the select or enable control pins. When SAB and SBA are in the real-time transfer mode, it is also possible to store data without using the internal D-type flip-flops by simultaneously enabling GAB and  $\bar{G}BA$ . In this configuration each output reinforces its input. Thus, when all other data sources to the two sets of bus lines are at high impedance, each set of bus lines will remain at its last state.

The SN54HCT651 and SN54HCT652 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT651 and SN74HCT652 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT651, SN54HCT652... JT PACKAGE  
SN74HCT651, SN74HCT652... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



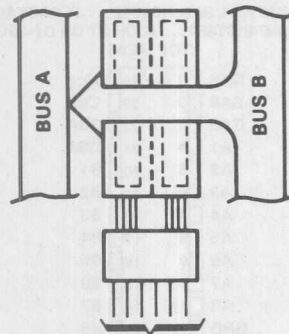
SN54HCT651, SN54HCT652... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

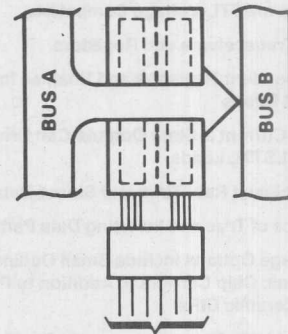
3

HCMOS DEVICES



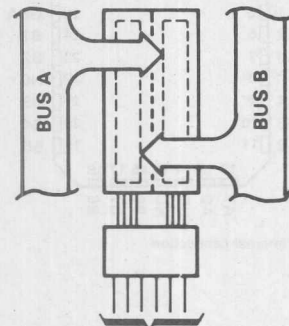
(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
L	L	X	X	X	L

REAL-TIME TRANSFER  
BUS B TO BUS A



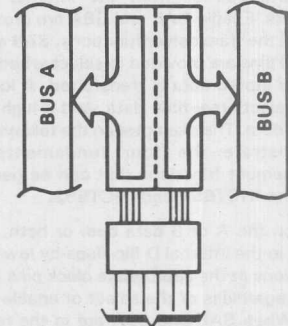
(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
H	H	X	X	L	X

REAL-TIME TRANSFER  
BUS A TO BUS B



(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
X	H	↑	X	X	X
L	X	X	↑	X	X
L	H	↑	↑	X	X

STORAGE FROM  
A AND/OR B



(3)	(21)	(1)	(23)	(2)	(22)
GAB	$\overline{\text{GBA}}$	CAB	CBA	SAB	SBA
H	L	H or L	H or L	H	H

TRANSFER  
STORED DATA  
TO A AND/OR B

Pin numbers shown are for JT and NT packages.

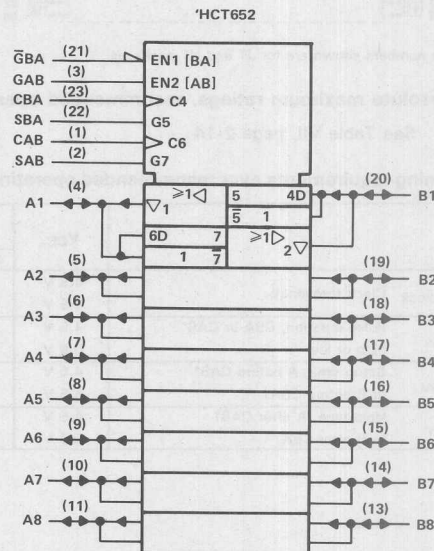
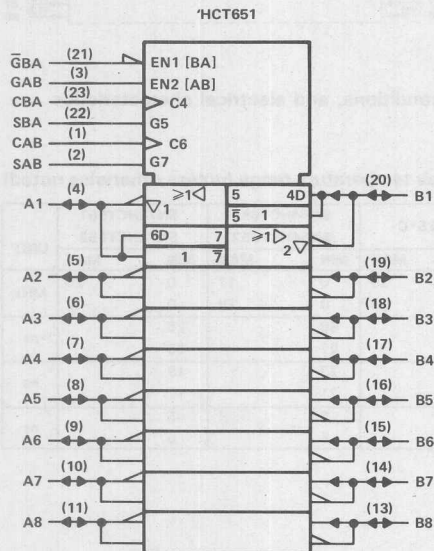
# TYPES SN54HCT651, SN54HCT652, SN74HCT651, SN74HCT652 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

FUNCTION TABLE

INPUTS						DATA I/O†		OPERATION OR FUNCTION	
GAB	$\bar{G}BA$	CAB	CBA	SAB	SBA	A1 THRU A8	B1 THRU B8	'HCT651	'HCT652
L	H	H or L	H or L	X	X	Input	Input	Isolation	Isolation
L	H	↑	↑	X	X			Store A and B Data	Store A and B Data
X	H	↑	H or L	X	X	Input	Not specified	Store A, Hold B	Store A, Hold B
H	H	↑	↑	X	X			Store A in both registers	Store A in both registers
L	X	H or L	↑	X	X	Not specified	Input	Hold A, Store B	Hold A, Store B
L	L	↑	↑	X	X			Store B in both registers	Store B in both registers
L	L	X	X	X	L	Output	Input	Real-Time $\bar{B}$ Data to A Bus	Real-Time B Data to A Bus
L	L	X	H or L	X	H			Stored $\bar{B}$ Data to A Bus	Stored B Data to A Bus
H	H	X	X	L	X	Input	Output	Real-Time $\bar{A}$ Data to B Bus	Real-Time A Data to B Bus
H	H	H or L	X	H	X			Stored $\bar{A}$ Data to B Bus	Stored A Data to B Bus
H	L	H or L	H or L	H	H	Output	Output	Stored $\bar{A}$ Data to B Bus and Stored $\bar{B}$ Data to A Bus	Stored A Data to B Bus and Stored B Data to A Bus

† The data output functions may be enabled or disabled by various signals at the GAB and  $\bar{G}BA$  inputs. Data input functions are always enabled, i.e., data at the bus pins will be stored on every low-to-high transition on the clock inputs.

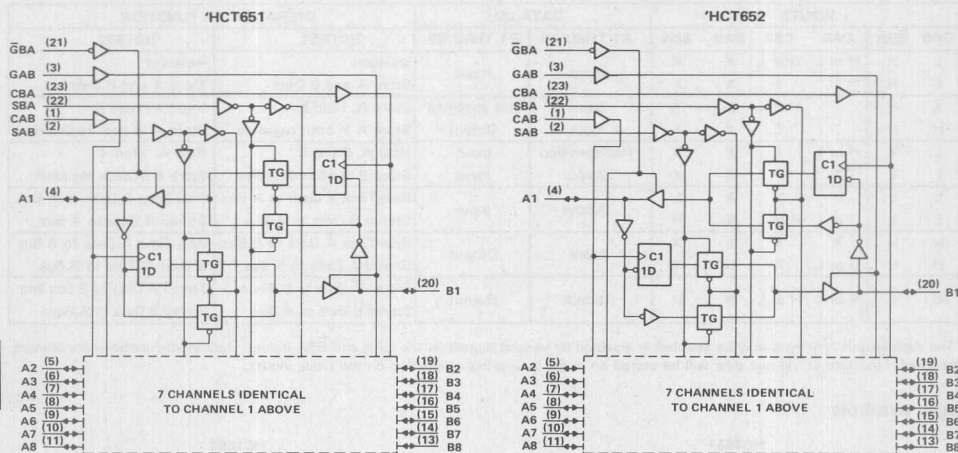
## logic symbols



Pin numbers shown are for JT and NT packages.

# TYPES SN54HCT651, SN54HCT652, SN74HCT651, SN74HCT652 OCTAL BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT651 SN54HCT652		SN74HCT651 SN74HCT652		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	4.5 V	0	25	0	17	0	20	MHz
	5.5 V	0	28	0	19	0	22	
t <sub>w</sub> Pulse duration, CBA or CAB high or low	4.5 V	20		30		25		ns
	5.5 V	18		27		23		
t <sub>su</sub> Setup time, A before CAB† or B before CBA†	4.5 V	15		23		19		ns
	5.5 V	14		21		17		
t <sub>h</sub> Hold time, A after CAB† or B after CBA†	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

# **TYPES SN54HCT651, SN54HCT652, SN74HCT651, SN74HCT652** **OCTAL BUS TRANSCEIVERS AND REGISTERS** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT651 SN54HCT652		SN74HCT652 SN74HCT652		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			4.5 V 5.5 V	25 28	35 40		17 19		20 22		MHz
$t_{\text{pd}}$	CBA or CAB	A or B	4.5 V 5.5 V		18 16	36 32		54 49		45 41	ns
$t_{\text{pd}}$	A or B	B or A	4.5 V 5.5 V		14 12	27 24		41 37		34 31	ns
$t_{\text{pd}}$	SBA or SAB <sup>†</sup>	A or B	4.5 V 5.5 V		20 17	38 34		57 51		48 43	ns
$t_{\text{en}}$	$\overline{\text{G}}$ BA or GAB	A or B	4.5 V 5.5 V		25 22	49 44		74 67		61 55	ns
$t_{\text{dis}}$	$\overline{\text{G}}$ BA or GAB	A or B	4.5 V 5.5 V		25 22	49 44		74 67		61 55	ns
$t_t$		Any	4.5 V 5.5 V		9 7	12 11		18 16		15 14	ns

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT651 SN54HCT652		SN74HCT651 SN74HCT652		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{\text{pd}}$	CBA or CAB	A or B	4.5 V 5.5 V		24 22	53 47		80 72		66 60	ns
$t_{\text{pd}}$	A or B	B or A	4.5 V 5.5 V		22 20	44 39		70 60		55 50	ns
$t_{\text{pd}}$	SBA or SAB <sup>†</sup>	A or B	4.5 V 5.5 V		26 24	55 49		83 74		69 62	ns
$t_{\text{en}}$	$\overline{\text{G}}$ BA or GAB	A or B	4.5 V 5.5 V		33 30	66 59		100 90		82 74	ns
$t_t$		Any	4.5 V 5.5 V		17 14	42 38		63 57		53 48	ns

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

<sup>†</sup>These parameters are measured with the internal output state of the storage register opposite to that of the bus input.

3

HCMOS DEVICES





- Bus Transceivers with Inverting Outputs ('HC658) or True Outputs ('HC659)
- Generates a Parity Bit for A Bus and B Bus
- Easily Cascadable
- Internal Active Pull-Ups and Pull-Downs
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

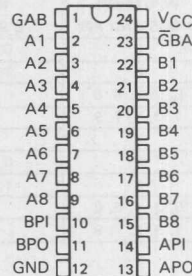
#### description

These octal bus transceivers are designed for asynchronous, bidirectional communication between data buses. The devices transmit data from the A Bus to the B Bus or from the B Bus to the A Bus, depending on the level at the direction control inputs, GAB and  $\bar{G}BA$ . These devices also generate parity outputs, APO and BPO, which reflect the number of high levels at the A Bus and B Bus, respectively, taking into account the parity inputs API and BPI.

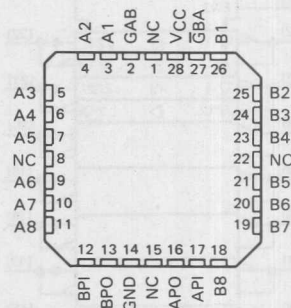
The bidirectional I/O ports feature active circuitry on the input stage that, when the output shared by that pin is disabled, will maintain the input in the last state taken by the output. This state will be maintained until changed by activity on the bus. The advantage of this arrangement is that when all outputs on the bus are disabled, the inputs will be prevented from floating, resulting in minimum power dissipation and minimum susceptibility to noise. This eliminates any need for external pull-up or pull-down resistors. The parity inputs API and BPI have similar circuits. For further information, see Typical Application Data.

The SN54HC658 and SN54HC659 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC658 and SN75HC659 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC658, SN54HC659 ... JT PACKAGE  
SN74HC658, SN74HC659 ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC658, SN54HC659 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES

**TYPES SN54HC658, SN54HC659, SN74HC658, SN74HC659**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

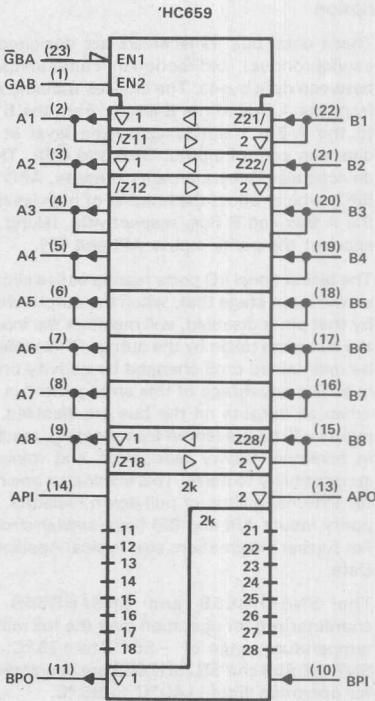
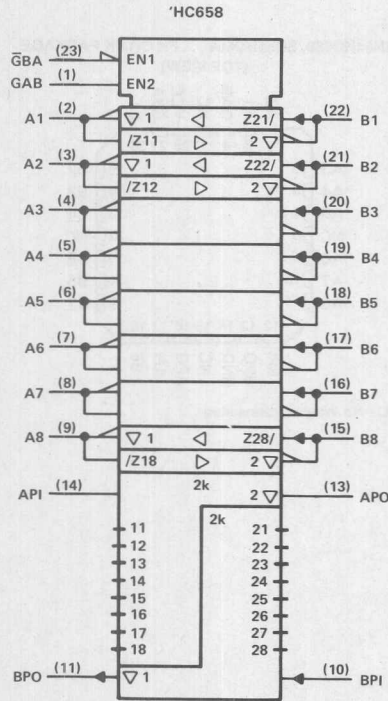
FUNCTION TABLE

CONTROL INPUTS		NUMBER OF HIGH INPUTS ON A BUS AND API	NUMBER OF HIGH INPUTS ON B BUS AND BPI	OUTPUTS		OPERATION	
GBA	GAB			APO	BPO	'HC658	'HC659
L	L	X	0, 2, 4, 6, 8	Z	H	$\overline{B}$ Data to A Bus	B Data to A Bus
		X	1, 3, 5, 7, 9	Z	L		
H	H	0, 2, 4, 6, 8	X	H	Z	$\overline{A}$ Data to B Bus	A Data to B Bus
		1, 3, 5, 7, 9	X	L	Z		
H	L	X	X	Z	Z	Isolation	Isolation
L	H	X	0, 2, 4, 6, 8		H	$\overline{B}$ Data to A Bus, $\overline{A}$ Data to B Bus	B Data to A Bus, A Data to B Bus
		X	1, 3, 5, 7, 9		L		
		0, 2, 4, 6, 8	X	H			
		1, 3, 5, 7, 9	X	L			

logic symbols

3

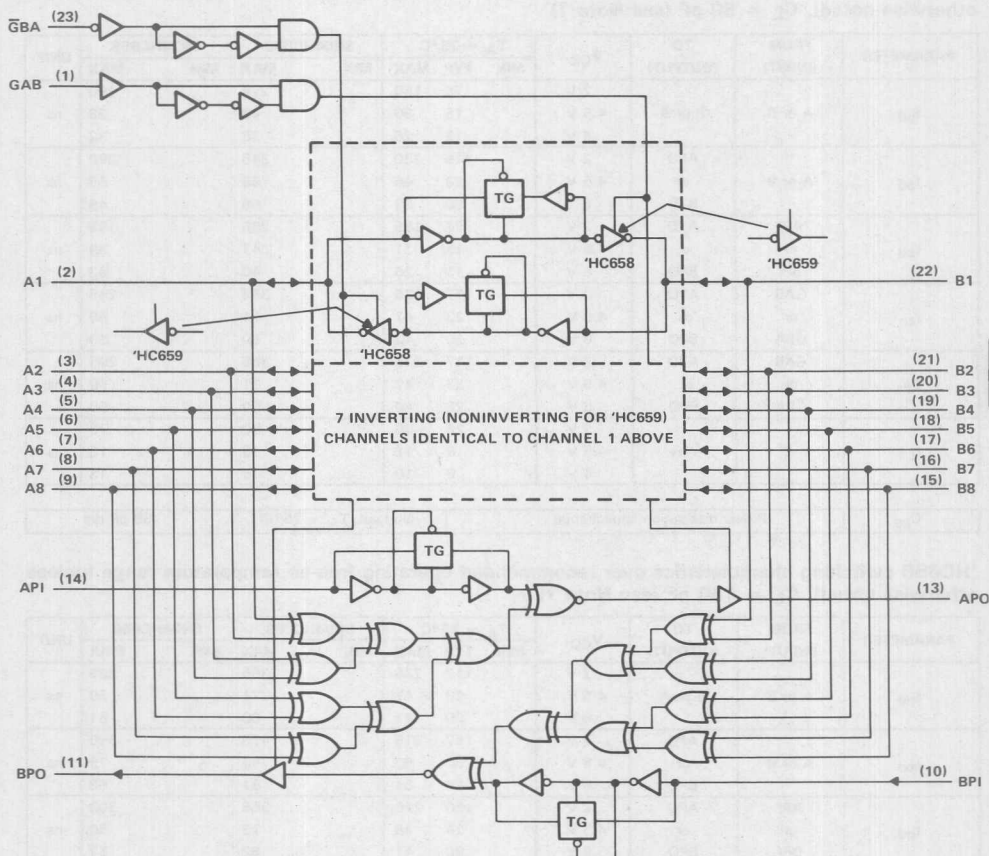
HCMOS DEVICES



Pin numbers shown are for JT and NT packages.

# TYPES SN54HC658, SN54HC659, SN74HC658, SN74HC659 OCTAL BUS TRANSCEIVERS WITH PARITY

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

Because of the nature of the transceiver I/O ports and the parity inputs, the following additional parameter also applies. It is the peak current as the input changes from 0 V to  $V_{CC}$ .

PARAMETER	TEST CONDITION	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC658 SN54HC659		SN74HC658 SN74HC659		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$I_{IM}$	$V_I = 0 \text{ to } V_{CC}$	6 V			$\pm 400$		$\pm 520$		$\pm 520$	$\mu\text{A}$

**TYPES SN54HC658, SN74HC658**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

'HC658 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC658		SN74HC658		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
t <sub>pd</sub>	A or B	APO	2 V		115	230		345		290	ns
		or	4.5 V		23	46		69		58	
		BPO	6 V		20	39		59		49	
t <sub>pd</sub>	API or BPI	APO or BPO	2 V		77	155		235		195	ns
		4.5 V		15	31		47		39		
		6 V		13	26		40		33		
t <sub>en</sub>	GAB or G̅BA	APO or BPO	2 V		117	235		355		295	ns
		4.5 V		23	47		71		59		
		6 V		20	40		60		50		
t <sub>dis</sub>	GAB or G̅BA	APO or BPO	2 V		117	235		355		295	ns
		4.5 V		23	47		71		59		
		6 V		20	40		60		50		
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	56 pF typ
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'HC658 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC658		SN74HC658		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	2 V		117	235		355		295	ns
			4.5 V		23	47		71		59	
			6 V		20	41		60		51	
t <sub>pd</sub>	A or B	APO	2 V		157	315		475		395	ns
		or	4.5 V		31	63		95		79	
		BPO	6 V		27	54		81		68	
t <sub>pd</sub>	API or BPI	APO	2 V		120	240		365		300	ns
		or	4.5 V		24	48		73		60	
		BPO	6 V		20	41		62		52	
t <sub>en</sub>	GAB or G $\overline{B}$ A	APO	2 V		160	320		485		400	ns
		or	4.5 V		32	64		97		80	
		BPO	6 V		27	55		82		69	
t <sub>t</sub>		Any	2 V		37	210		315		265	ns
			4.5 V		12	42		63		53	
			6 V		10	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES

# TYPES SN54HC659, SN74HC659 OCTAL BUS TRANSCEIVERS WITH PARITY

'HC659 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC659		SN74HC659		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		70	140		210		175	ns
			4.5 V		14	28		42		35	
			6 V		12	24		36		30	
$t_{pd}$	A or B	APO	2 V		115	230		345		290	ns
		or	4.5 V		23	46		69		58	
		BPO	6 V		20	39		59		49	
$t_{pd}$	API or BPI	APO	2 V		77	155		235		195	ns
		or	4.5 V		15	31		47		39	
		BPO	6 V		13	26		40		33	
$t_{en}$	GAB or $\overline{G}BA$	APO	2 V		117	235		355		295	ns
		or	4.5 V		23	47		71		59	
		BPO	6 V		20	40		60		50	
$t_{dis}$	GAB or $\overline{G}BA$	APO	2 V		117	235		355		295	ns
		or	4.5 V		23	47		71		59	
		BPO	6 V		20	40		60		50	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	56 pF typ
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'HC659 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC659		SN74HC659		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		117	225		340		280	ns
			4.5 V		23	45		68		56	
			6 V		20	39		58		49	
$t_{pd}$	A or B	APO	2 V		157	315		475		395	ns
		or	4.5 V		31	63		95		79	
		BPO	6 V		27	54		81		68	
$t_{pd}$	API or BPI	APO	2 V		120	240		365		300	ns
		or	4.5 V		24	48		73		60	
		BPO	6 V		20	41		62		52	
$t_{en}$	GAB or $\overline{G}BA$	APO	2 V		160	320		485		400	ns
		or	4.5 V		32	64		97		80	
		BPO	6 V		27	55		82		69	
$t_t$		Any	2 V		37	210		315		265	ns
			4.5 V		12	42		63		53	
			6 V		10	36		53		45	

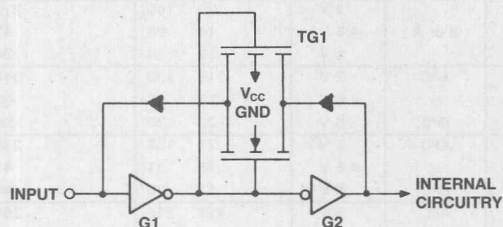
NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# **TYPES SN54HC658, SN54HC659, SN74HC658, SN74HC659** **OCTAL BUS TRANSCEIVERS WITH PARITY**

## **TYPICAL APPLICATION DATA**

The unique structure used on the I/O ports and the parity inputs of these devices deserves some special consideration (see Figure 1). Only the input structure is shown. The conventional 3-state output structure associated with each I/O port has been omitted to facilitate understanding



**FIGURE 1. INPUT STRUCTURE**

**3**

**HCMOS DEVICES**

The two inverters (G1 and G2) have a transmission gate (TG1) connected in a feedback loop around them. This transmission gate is connected in an unusual fashion, that is, with the gates of both transistors connected to the output of G1. Thus, with the output of G1 at either a high or a low level, one or the other of the transistors will be turned on allowing feedback of the output of G2 to the input of G1. The effect of TG1 is that the input level will be maintained at whatever level existed prior to the bus being disabled or the level currently existing on the bus will be reinforced.

To understand the operation of this input, assume that initially the input is at a low logic level. As the input voltage is raised, TG1 sinks current to attempt to maintain the low level. However, TG1 consists of small geometry transistors and appears resistive as current flows thus allowing the input voltage to rise toward the threshold voltage of G1. When the threshold voltage is reached, G1 changes state causing G2 to change state. G2 then attempts to maintain a high level on the input through TG1. A similar operation occurs when the input voltage is decreased toward the threshold voltage of G1. G2 sources current through TG1 until the threshold is reached.

This characteristic of the input stage has some implications for the input current levels. With the input held at either  $V_{CC}$  or GND, there is no voltage across TG1 and negligible input current. However, as the input voltage is raised from GND or lowered from  $V_{CC}$ , the input current rises as the voltage across TG1 increases. The input current continues to rise until it reaches a maximum just as the threshold voltage of G1 is reached. This maximum corresponds to parameter  $I_{IM}$  shown in the electrical characteristics table. Because G1 consists of small geometry transistors,  $I_{IM}$  has a value much lower than the output drive capability of a conventional 'HC output stage. Also for this reason, the input configuration has negligible effect when the I/O port is used as an output.

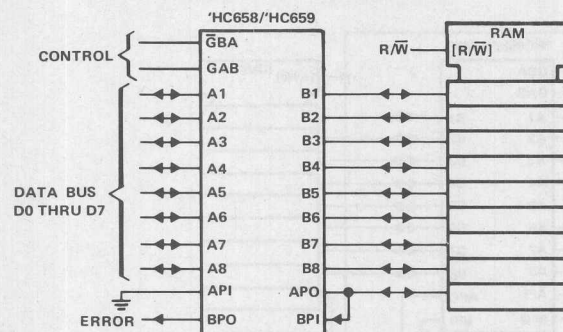
This configuration provides for minimum power dissipation when the bus is inactive (all outputs on the bus in the high-impedance state) and minimum susceptibility to noise on the bus during this time. The increase in input current may go unnoticed as it only occurs during transitions on the bus. Care must be taken when measuring input currents (e.g., at incoming inspection) to ensure that the input voltage is set to the correct value.

The use of these devices for interfacing to 8-, 16-, and 24-bit-wide memory arrays with parity is illustrated in Figures 2, 3, and 4.

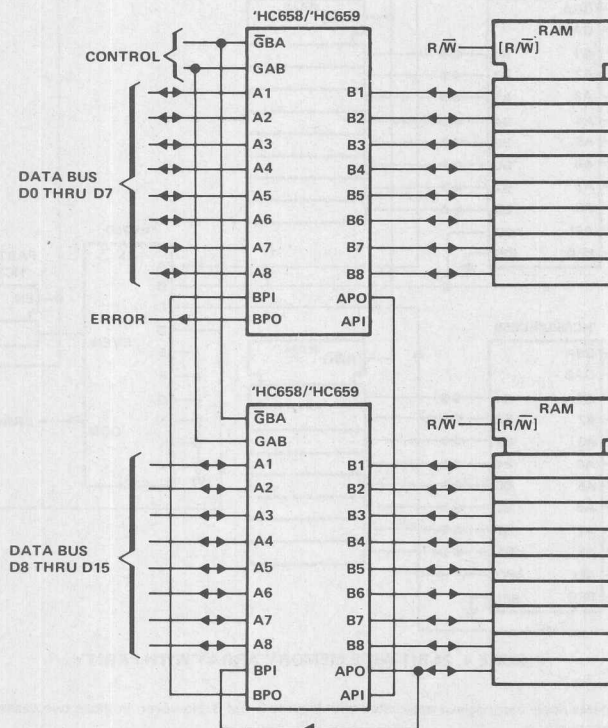


**TYPES SN54HC658, SN54HC659, SN74HC658, SN74HC659**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

**TYPICAL APPLICATION DATA**



**FIGURE 2. 8-BIT-WIDE MEMORY ARRAY WITH PARITY**



**FIGURE 3. 16-BIT-WIDE MEMORY ARRAY WITH PARITY**

**3**

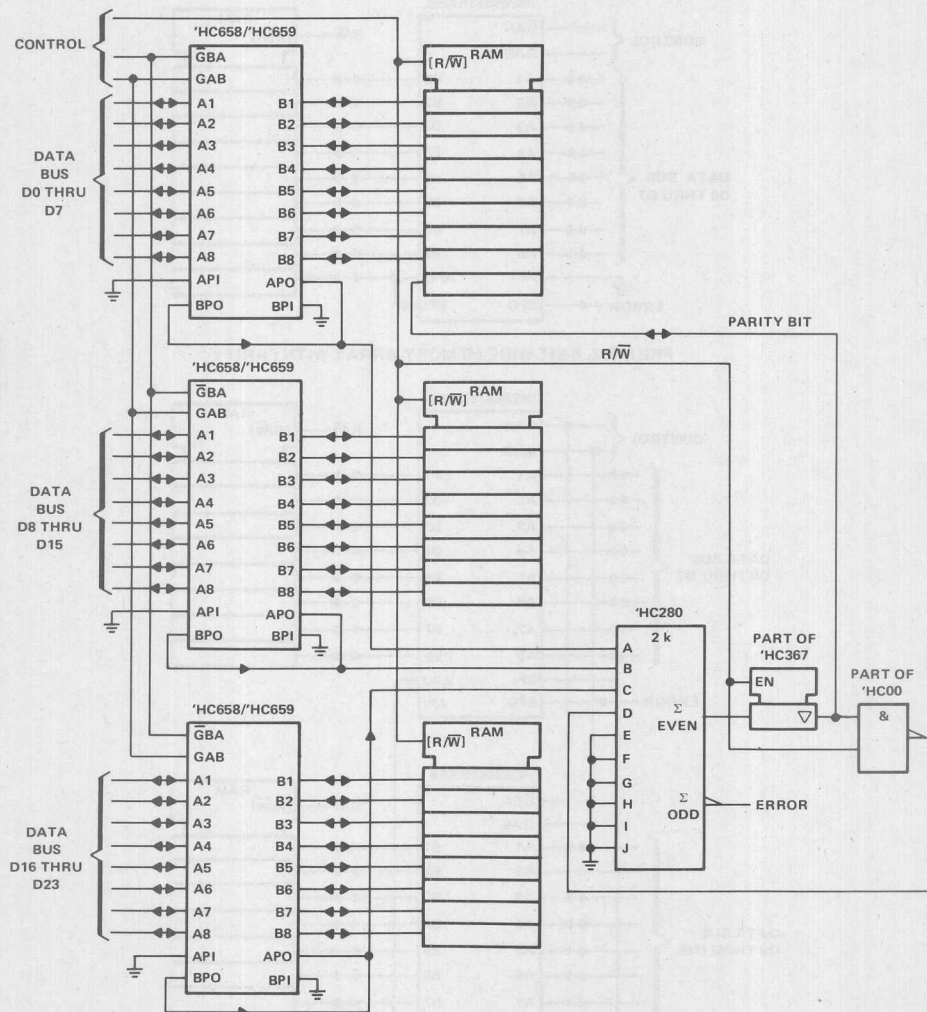
**HCMOS DEVICES**

**TYPES SN54HC658, SN54HC659, SN74HC658, SN74HC659**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

**TYPICAL APPLICATION DATA**

**3**

**HC MOS DEVICES**



**FIGURE 4. 24-BIT-WIDE MEMORY ARRAY WITH PARITY**

NOTE: The 'HC280 eliminates ripple carry delays associated with Figures 2 and 3. However, in those two cases the delays are probably too small to be of concern.

- Inputs are TT-Voltage Compatible
- Bus Transceivers with Inverting Outputs ('HCT658) or True Outputs ('HCT 659)
- Generates a Parity Bit for A Bus and B Bus
- Easily Cascadable
- Internal Active Pull-Ups and Pull-Downs
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

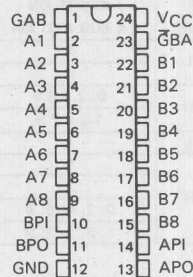
### description

These octal bus transceivers are designed for asynchronous, bidirectional communication between data buses. The devices transmit data from the A Bus to the B Bus, or from the B Bus to the A Bus, depending on the levels at the direction control inputs, GAB and GBA. These devices also generate parity outputs, APO and BPO, which reflect the number of high levels at the A Bus and B Bus, respectively, taking into account the parity inputs API and BPI.

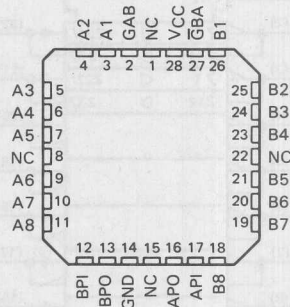
The bidirectional I/O ports feature active circuits on the input stage that, when the output shared by that pin is disabled, will maintain the input in the last state taken by the output. This state will be maintained until changed by activity on the bus. The advantage of this arrangement is that when all outputs on the bus are disabled, the inputs will be prevented from floating, resulting in minimum power dissipation and minimum susceptibility to noise. This eliminates any need for external pull-up or pull-down resistors. The parity inputs API and BPI have similar circuits. For further information, see Typical Application Data in 'HC658 series data sheet.

The SN54HCT658 and SN54HCT659 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT658 and SN74HCT659 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT658, SN54HCT659 ... JT PACKAGE  
SN74HC658, SN74HCT659 ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT658, SN54HCT659 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection.

TYPES SN54HCT658, SN54HCT659, SN74HCT658, SN74HCT659  
OCTAL BUS TRANSCEIVERS WITH PARITY

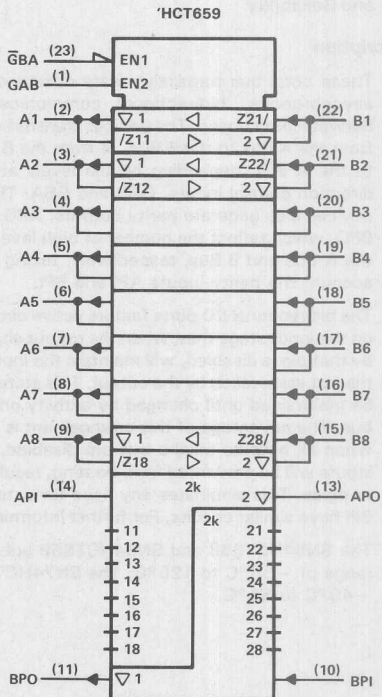
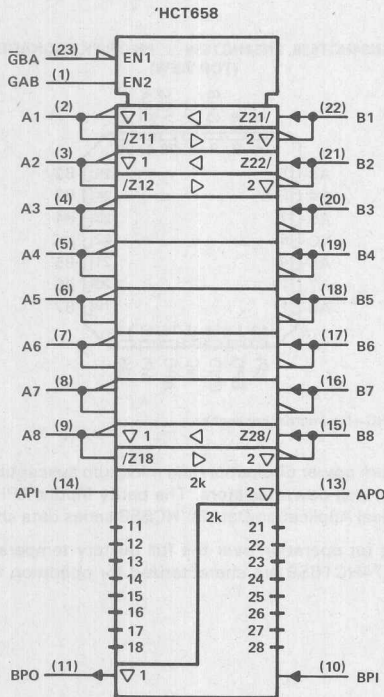
FUNCTION TABLE

CONTROL INPUTS		NUMBER OF HIGH INPUTS ON A BUS AND API	NUMBER OF HIGH INPUTS ON B BUS AND BPI	OUTPUTS		OPERATION	
$\overline{\text{GBA}}$	GAB			APO	BPO	'HCT658	'HCT659
L	L	X	0, 2, 4, 6, 8	Z	H	$\overline{\text{B}}$ Data to A Bus	B Data to A Bus
		X	1, 3, 5, 7, 9	Z	L		
H	H	0, 2, 4, 6, 8	X	H	Z	$\overline{\text{A}}$ Data to B Bus	A Data to B Bus
		1, 3, 5, 7, 9	X	L	Z		
H	L	X	X	Z	Z	Isolation	Isolation
L	H	X	0, 2, 4, 6, 8		H	$\overline{\text{B}}$ Data to A Bus, $\overline{\text{A}}$ Data to B Bus	B Data to A Bus, A Data to B Bus
		X	1, 3, 5, 7, 9		L		
		0, 2, 4, 6, 8	X	H			
		1, 3, 5, 7, 9	X	L			

logic symbols

3

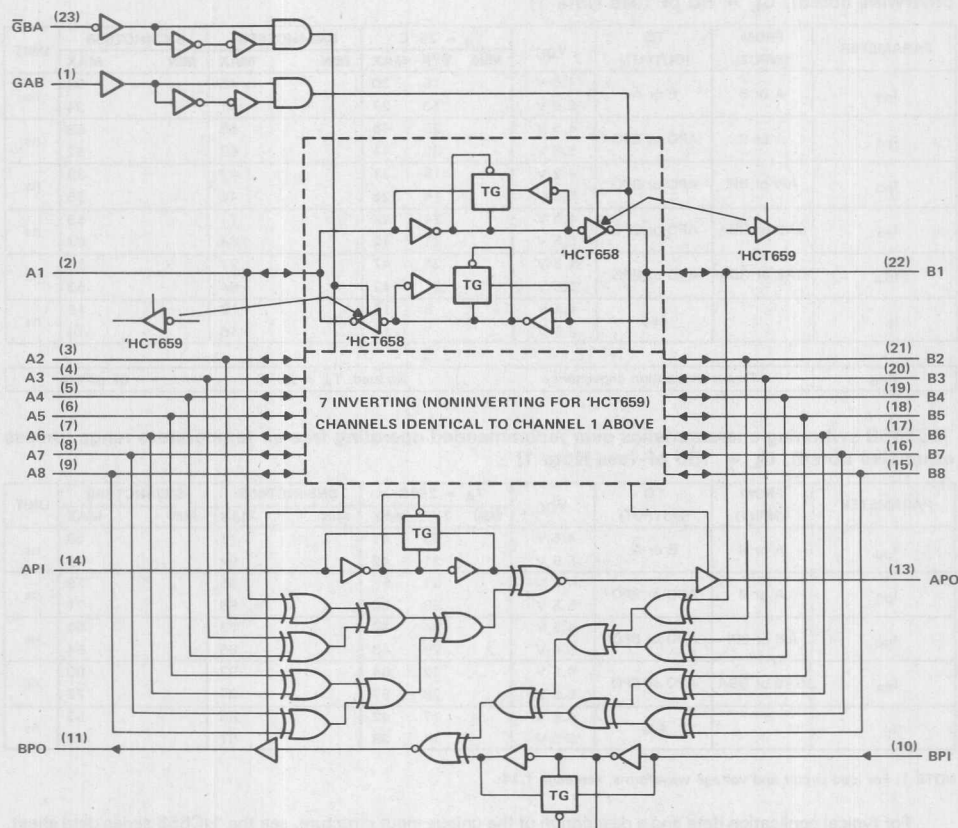
HCMOS DEVICES



Pin numbers shown are for JT and NT packages.

# TYPES SN54HCT658, SN54HCT659, SN74HCT658, SN74HCT659 OCTAL BUS TRANSCEIVERS WITH PARITY

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

Because of the nature of the transceiver I/O ports and the parity inputs, the following parameter also applies. It is the peak current as the input changes from 0 V to  $V_{CC}$ .

PARAMETER	TEST CONDITION	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT658 SN54HCT659		SN74HCT658 SN74HCT659		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$I_{IM}$	$V_I = 0 \text{ to } V_{CC}$	5.5 V			$\pm 400$		$\pm 520$		$\pm 520$	$\mu\text{A}$



# TYPES SN54HCT658, SN74HCT658 OCTAL BUS TRANSCEIVERS WITH PARITY

'HCT658 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT658		SN74HCT658		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		15	30		45		38	ns
			5.5 V		13	27		41		34	
t <sub>pd</sub>	A or B	APO or BPO	4.5 V		23	46		69		58	ns
			5.5 V		20	41		62		52	
t <sub>pd</sub>	API or BPI	APO or BPO	4.5 V		15	31		47		39	ns
			5.5 V		14	28		42		35	
t <sub>en</sub>	GAB or $\overline{\text{G}}\text{BA}$	APO or BPO	4.5 V		24	47		71		59	ns
			5.5 V		21	42		64		53	
t <sub>dis</sub>	GAB or $\overline{\text{G}}\text{BA}$	APO or BPO	4.5 V		24	47		71		59	ns
			5.5 V		21	42		64		53	
t <sub>t</sub>		Any	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

3

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	62 pF typ
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'HCT658 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT658		SN74HCT658		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		23	47		71		59	ns
			5.5 V		21	42		64		53	
t <sub>pd</sub>	A or B	APO or BPO	4.5 V		31	63		95		79	ns
			5.5 V		28	56		85		71	
t <sub>pd</sub>	API or BPI	APO or BPO	4.5 V		24	48		73		60	ns
			5.5 V		21	43		65		54	
t <sub>en</sub>	GAB or $\overline{\text{G}}\text{BA}$	APO or BPO	4.5 V		32	64		97		80	ns
			5.5 V		28	57		87		72	
t <sub>t</sub>		Any	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

For typical application data and a description of the unique input structure, see the 'HC658 series data sheet.

HC MOS DEVICES



# TYPES SN54HCT659, SN74HCT659 OCTAL BUS TRANSCEIVERS WITH PARITY

'HCT659 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT659		SN74HCT659		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		14	28		42		35	ns
			5.5 V		12	25		61		50	
$t_{pd}$	A or B	APO or BPO	4.5 V		23	46		69		58	ns
			5.5 V		20	41		62		52	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		15	31		47		39	ns
			5.5 V		14	28		42		35	
$t_{en}$	GAB or $\overline{\text{GBA}}$	APO or BPO	4.5 V		24	47		71		59	ns
			5.5 V		21	42		64		53	
$t_{dis}$	GAB or $\overline{\text{GBA}}$	APO or BPO	4.5 V		24	47		71		59	ns
			5.5 V		21	42		64		53	
$t_t$		Any	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	62 pF typ
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'HCT659 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT659		SN74HCT659		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		23	45		68		56	ns
			5.5 V		20	40		84		67	
$t_{pd}$	A or B	APO or BPO	4.5 V		32	63		95		79	ns
			5.5 V		28	56		85		71	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		24	48		73		60	ns
			5.5 V		21	43		65		54	
$t_{en}$	GAB or $\overline{\text{GBA}}$	APO or BPO	4.5 V		32	64		97		80	ns
			5.5 V		29	57		87		72	
$t_t$		Any	4.5 V		21	42		63		53	ns
			5.5 V		19	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

For typical application data and a description of the unique input structure, see the 'HC658 series data sheet.

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HCMOS DEVICES

## HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665 OCTAL BUS TRANSCEIVERS WITH PARITY

D2839, MARCH 1984

- Bus Transceivers with Inverting Outputs ('HC664) or True Outputs ('HC665)
- Generates a Parity Bit for A Bus and B Bus
- Easily Cascadable
- Internal Active Pull-Ups and Pull-Downs
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

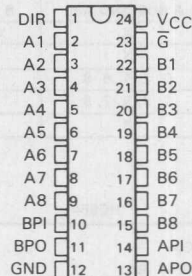
### description

These octal bus transceivers are designed for asynchronous, bidirectional communication between data buses. The devices transmit data from the A Bus to the B Bus or from the B Bus to the A Bus, depending on the level at the direction control input, DIR. The enable input,  $\bar{G}$ , can be used to disable the device so that the buses are isolated. These devices will also generate parity outputs, APO and BPO, which reflect the number of high levels at the A Bus and B Bus, respectively, taking into account the parity inputs API and BPI.

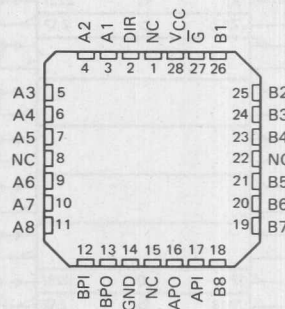
The bidirectional I/O ports feature active circuitry on the input stage that, when the output shared by that pin is disabled, will maintain the input in the last state taken by the output. This state will be maintained until changed by the activity on the bus. The advantage of this arrangement is that when all outputs on the bus are disabled, the inputs will be prevented from floating, resulting in minimum power dissipation and minimum susceptibility to noise. This eliminates any need for external pull-up or pull-down resistors. The parity inputs API and BPI have similar circuitry. For further information, see the Typical Application Data.

The SN54HC664 and SN54HC665 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC664 and SN74HC665 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC664, SN54HC665 ... JT PACKAGE  
SN74HC664, SN74HC665 ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC664, SN54HC665 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

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HCMOS DEVICES

# TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665 OCTAL BUS TRANSCEIVERS WITH PARITY

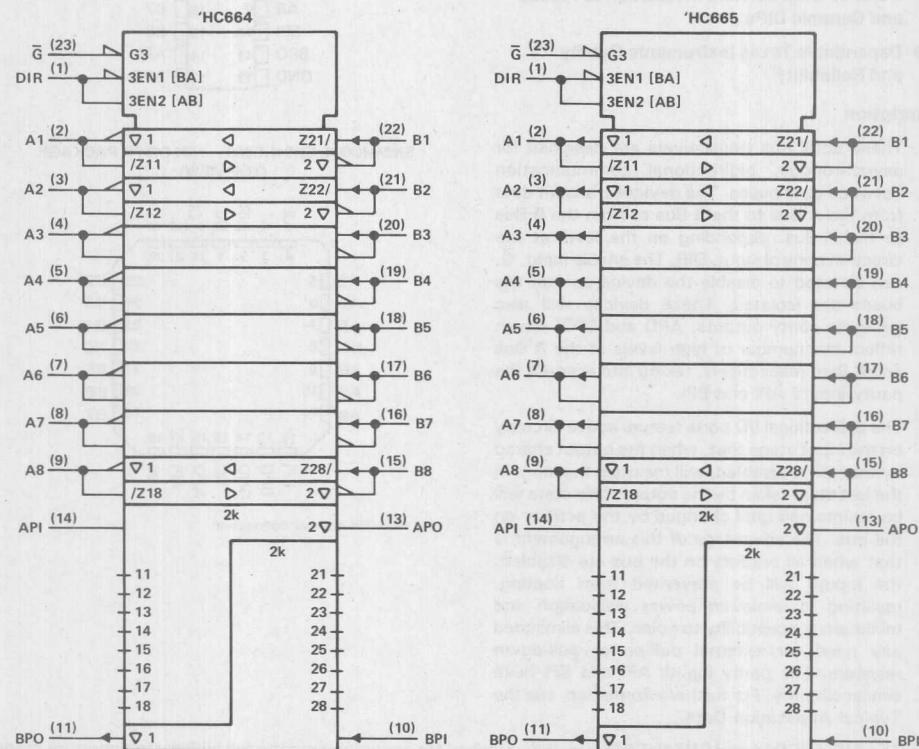
FUNCTION TABLE

CONTROL INPUTS		NUMBER OF HIGH INPUTS ON A BUS AND API	NUMBER OF HIGH INPUTS ON B BUS AND BPI	OUTPUTS		OPERATION	
$\bar{G}$	DIR			APO	BPO	'HC664	'HC665
L	L	X	0, 2, 4, 6, 8	Z	H	$\bar{B}$ Data to A Bus	B Data to A Bus
		X	1, 3, 5, 7, 9	Z	L		
L	H	0, 2, 4, 6, 8	X	H	Z	$\bar{A}$ Data to B Bus	A Data to B Bus
		1, 3, 5, 7, 9	X	L	Z		
H	X	X	X	Z	Z	Isolation	Isolation

## logic symbols

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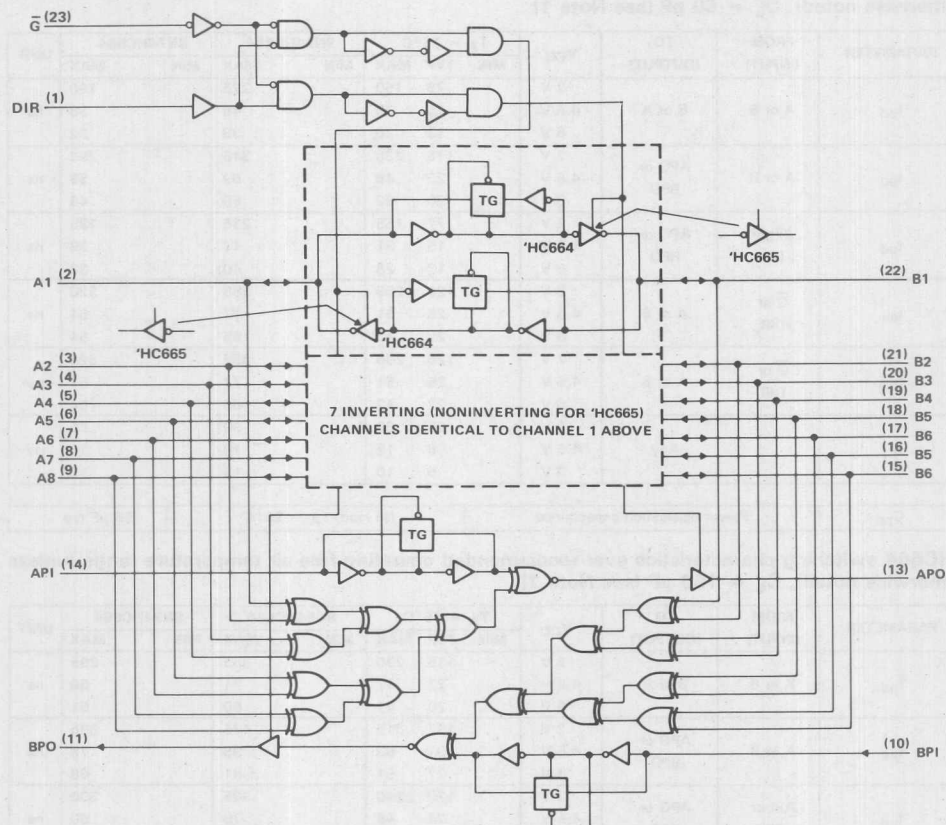
HC MOS DEVICES



Pin numbers shown are for JT and NT packages.

# TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665 OCTAL BUS TRANSCEIVERS WITH PARITY

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

Because of the nature of the transceiver I/O ports and the parity inputs, the following additional parameter applies. It is the peak current as the input changes from 0 V to  $V_{CC}$ .

PARAMETER	TEST CONDITION	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC664 SN54HC665	SN74HC664 SN74HC665	UNIT	
			MIN	TYP	MAX	MIN	MAX		MIN
I <sub>IM</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub>	6 V			±400		±520	±520	μA

# TYPES SN54HC664, SN74HC664 OCTAL BUS TRANSCEIVERS WITH PARITY

'HC664 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC664		SN74HC664		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		75	150		225		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{pd}$	A or B	APO or BPO	2 V		115	230		345		290	ns
			4.5 V		23	46		69		58	
			6 V		20	39		59		49	
$t_{pd}$	API or BPI	APO or BPO	2 V		77	155		235		195	ns
			4.5 V		15	31		47		39	
			6 V		13	26		40		33	
$t_{en}$	$\overline{G}$ or DIR	A or B	2 V		125	255		385		320	ns
			4.5 V		25	51		77		64	
			6 V		22	43		65		54	
$t_{dis}$	$\overline{G}$ or DIR	A or B	2 V		125	255		385		320	ns
			4.5 V		25	51		77		64	
			6 V		22	43		65		54	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	56 pF typ
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'HC664 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC664		SN74HC664		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		116	235		355		295	ns
			4.5 V		23	47		71		59	
			6 V		20	41		60		51	
$t_{pd}$	A or B	APO or BPO	2 V		157	315		475		395	ns
			4.5 V		31	63		95		79	
			6 V		27	54		81		68	
$t_{pd}$	API or BPI	APO or BPO	2 V		120	240		365		300	ns
			4.5 V		24	48		73		60	
			6 V		20	41		62		52	
$t_{en}$	$\overline{G}$ or DIR	A or B	2 V		170	340		515		425	ns
			4.5 V		34	68		103		85	
			6 V		29	58		87		73	
$t_t$		Any	2 V		37	210		315		265	ns
			4.5 V		12	42		63		53	
			6 V		10	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# TYPES SN54HC665, SN74HC665 OCTAL BUS TRANSCEIVERS WITH PARITY

'HC665 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC665		SN74HC665		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		70	140		210		175	ns
			4.5 V		14	28		42		35	
			6 V		12	24		36		30	
$t_{pd}$	A or B	APO or BPO	2 V		115	230		345		290	ns
			4.5 V		23	46		69		58	
			6 V		20	39		59		49	
$t_{pd}$	API or BPI	APO or BPO	2 V		77	155		235		195	ns
			4.5 V		15	31		47		39	
			6 V		13	26		40		33	
$t_{en}$	$\bar{G}$ or DIR	A or B	2 V		125	255		385		320	ns
			4.5 V		25	51		77		64	
			6 V		22	43		65		54	
$t_{dis}$	$\bar{G}$ or DIR	A or B	2 V		125	255		385		320	ns
			4.5 V		25	51		77		64	
			6 V		22	43		65		54	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	56 pF typ
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'HC665 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC665		SN74HC665		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	2 V		112	225		340		280	ns
			4.5 V		22	45		68		56	
			6 V		20	39		58		49	
$t_{pd}$	A or B	APO or BPO	2 V		157	315		475		395	ns
			4.5 V		31	63		95		79	
			6 V		27	54		81		68	
$t_{pd}$	API or BPI	APO or BPO	2 V		120	240		365		300	ns
			4.5 V		24	48		73		60	
			6 V		20	41		62		52	
$t_{en}$	$\bar{G}$ or DIR	A or B	2 V		170	340		515		425	ns
			4.5 V		34	68		103		85	
			6 V		29	58		87		73	
$t_t$		Any	2 V		37	210		315		265	ns
			4.5 V		12	42		63		53	
			6 V		10	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665 OCTAL BUS TRANSCEIVERS WITH PARITY

## TYPICAL APPLICATION DATA

The unique structure used on the I/O ports and the parity inputs of these devices deserves some special consideration (see Figure 1). Only the input structure is shown. The conventional 3-state output structure associated with each I/O port has been omitted to facilitate understanding.

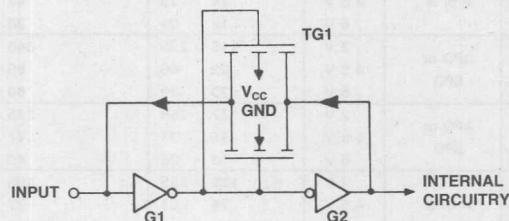


FIGURE 1. INPUT STRUCTURE

The two inverters (G1 and G2) have a transmission gate (TG1) connected in a feedback loop around them. This transmission gate is connected in an unusual fashion, that is, with the gates of both transistors connected to the output of G1. Thus, with the output of G1 at either a high or a low level, one or the other of the transistors will be turned on allowing feedback of the output of G2 to the input of G1. The effect of TG1 is that the input level will be maintained at whatever level existed prior to the bus being disabled or the level currently existing on the bus will be reinforced.

To understand the operation of this input, assume that initially the input is at a low logic level. As the input voltage is raised, TG1 sinks current to attempt to maintain the low level. However, TG1 consists of small geometry transistors and appears resistive as current flows thus allowing the input voltage to rise toward the threshold voltage of G1. When the threshold voltage is reached, G1 changes state causing G2 to change state. G2 then attempts to maintain a high level on the input through TG1. A similar operation occurs when the input voltage is decreased toward the threshold voltage of G1. G2 sources current through TG1 until the threshold is reached.

This characteristic of the input stage has some implications for the input current levels. With the input held at either  $V_{CC}$  or GND, there is no voltage across TG1 and negligible input current. However, as the input voltage is raised from GND or lowered from  $V_{CC}$ , the input current rises as the voltage across TG1 increases. The input current continues to rise until it reaches a maximum just as the threshold voltage of G1 is reached. This maximum corresponds to parameter  $I_{IM}$  shown in the electrical characteristics table. Because G1 consists of small geometry transistors,  $I_{IM}$  has a value much lower than the output drive capability of a conventional 'HC output stage. Also for this reason, the input configuration has negligible effect when the I/O port is used as an output.

This configuration provides for minimum power dissipation when the bus is inactive (all outputs on the bus in the high-impedance state) and minimum susceptibility to noise on the bus during this time. The increase in input current may go unnoticed as it only occurs during transitions on the bus. Care must be taken when measuring input currents (e.g., at incoming inspection) to ensure that the input voltage is set to the correct value.

The use of these devices for interfacing to 8-, 16-, 24-bit-wide memory arrays with parity is illustrated in Figures 2, 3, and 4.

3

HCMOS DEVICES

TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665  
OCTAL BUS TRANSCEIVERS WITH PARITY

TYPICAL APPLICATION DATA

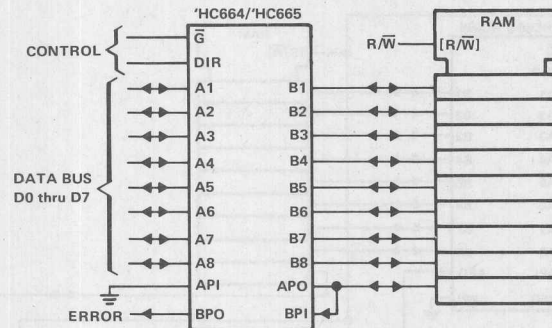


FIGURE 2. 8-BIT-WIDE MEMORY ARRAY WITH PARITY

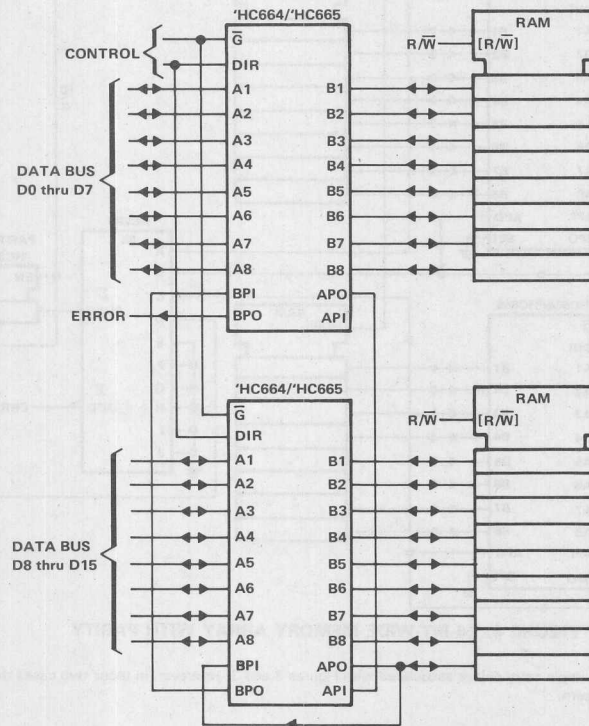


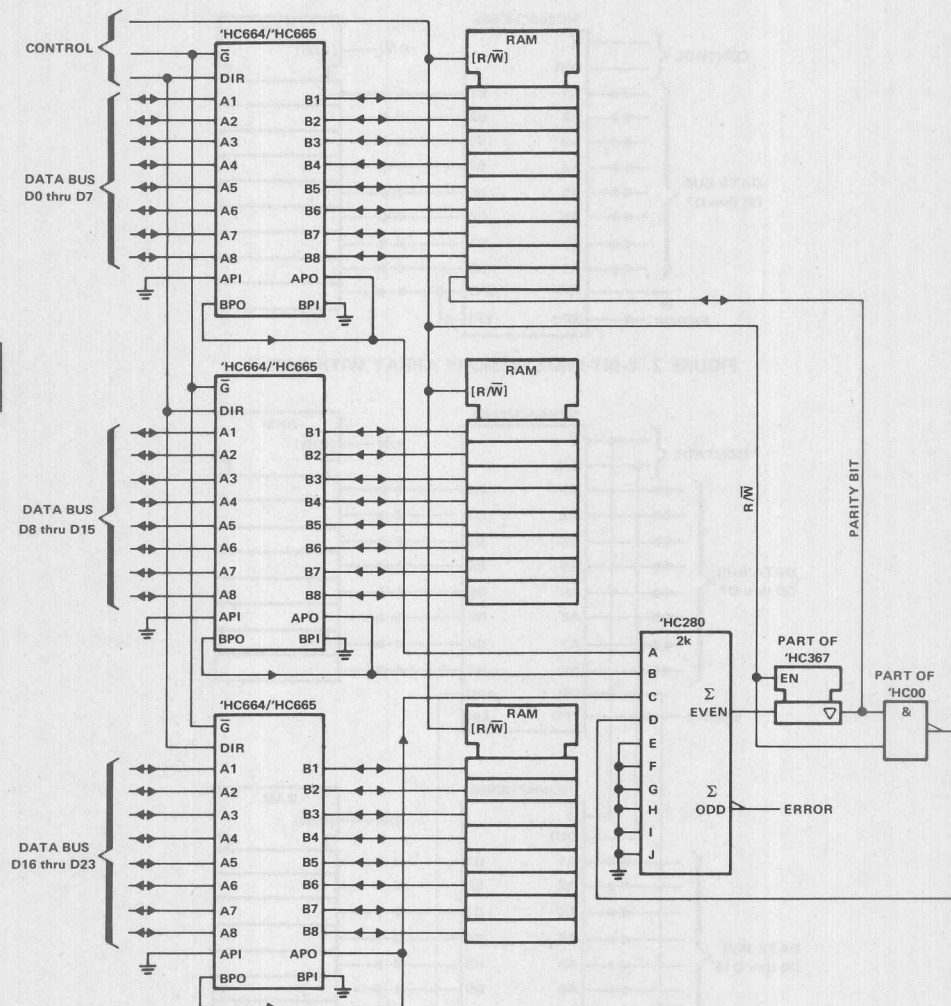
FIGURE 3. 16-BIT-WIDE MEMORY ARRAY WITH PARITY

**TYPES SN54HC664, SN54HC665, SN74HC664, SN74HC665**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

**TYPICAL APPLICATION DATA**

**3**

**HCMOS DEVICES**



**FIGURE 4. 24-BIT-WIDE MEMORY ARRAY WITH PARITY**

NOTE: The 'HC280 eliminates ripple carry delays associated with Figures 2 and 3. However, in those two cases the delays are probably too small to be of concern.

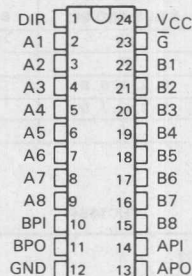
# HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT664, SN54HCT665, SN74HCT664, SN74HCT665 OCTAL BUS TRANSCEIVERS WITH PARITY

D2839, MARCH 1984

- Inputs Are TTL-Voltage Compatible
- Bus Transceivers with Inverting Outputs ('HCT664) or True Outputs ('HCT665)
- Generates a Parity Bit for A Bus and B Bus
- Easily Cascadable
- Internal Active Pull-Ups and Pull-Downs
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HCT664, SN54HCT665 . . . JT PACKAGE  
SN74HCT664, SN74HCT665 . . . JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



### description

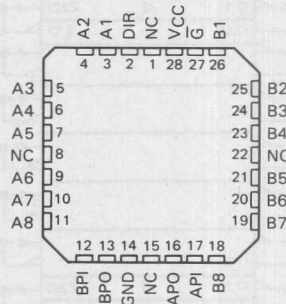
These octal bus transceivers are designed for asynchronous, bidirectional communication between data buses. The devices transmit data from the A Bus to the B Bus or from the B Bus to the A Bus, depending on the level at the direction control input, DIR. The enable input,  $\bar{G}$ , can be used to disable the device so that the buses are isolated. These devices will also generate parity outputs, APO and BPO, which reflect the number of high levels at the A Bus and B Bus, respectively, taking into account the parity inputs API and BPI.

The bidirectional I/O ports feature active circuitry on the input stage that, when the output shared by that pin is disabled, will maintain the input in the last state taken by the output. This state will be maintained until changed by the activity on the bus. The advantage of this arrangement is that when all outputs on the bus are disabled, the inputs will be prevented from floating, resulting in minimum power dissipation and minimum susceptibility to noise. This eliminates any need for external pull-up or pull-down resistors. The parity inputs API and BPI have similar circuitry. For further information, see the Typical Application Data on the 'HC664, and 'HC665 data sheet.

The input threshold voltages on these devices are adjusted to be TTL compatible, allowing direct interface to TTL levels on the bus or to memories with TTL output voltage levels.

The SN54HCT664 and SN54HCT665 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT664 and SN74HCT665 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT664, SN54HCT665 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES



**TYPES SN54HCT664, SN54HCT665, SN74HCT664, SN74HCT665**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

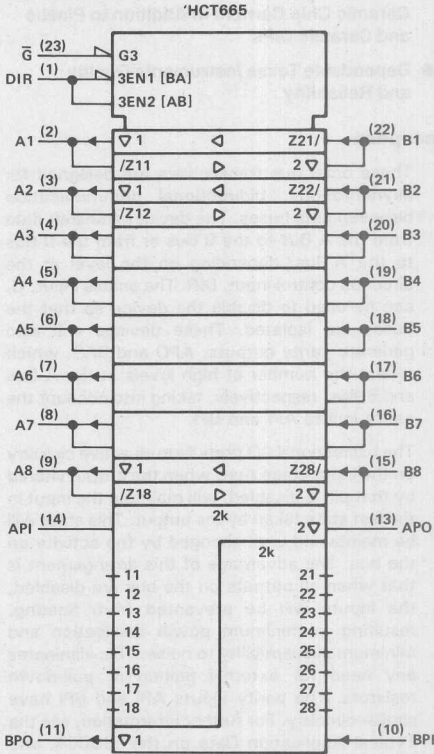
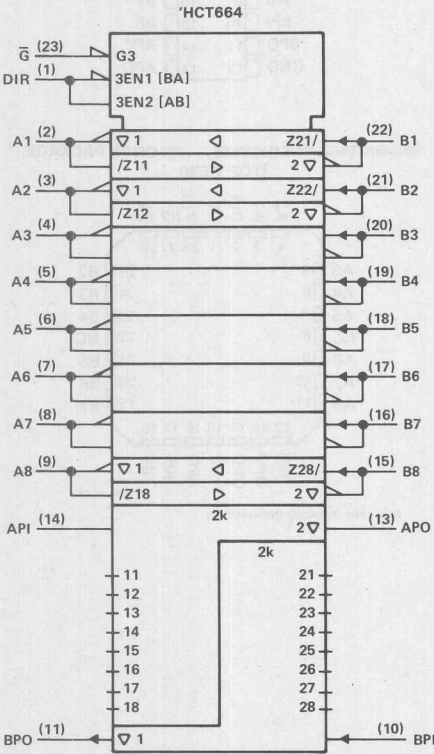
FUNCTION TABLE

CONTROL INPUTS		NUMBER OF HIGH INPUTS ON B BUS AND BPI	NUMBER OF HIGH INPUTS ON B BUS AND BPI	OUTPUTS		OPERATION	
$\bar{G}$	DIR			APO	BPO	'HCT664	'HCT665
L	L	X	0, 2, 4, 6, 8	Z	H	$\bar{B}$ Data to A Bus	B Data to A Bus
		X	1, 3, 5, 7, 9	Z	L		
L	H	0, 2, 4, 6, 8	X	H	Z	$\bar{A}$ Data to B Bus	A Data to B Bus
		1, 3, 5, 7, 9	X	L	Z		
H	X	X	X	Z	Z	Isolation	Isolation

logic symbols

3

HCMOS DEVICES

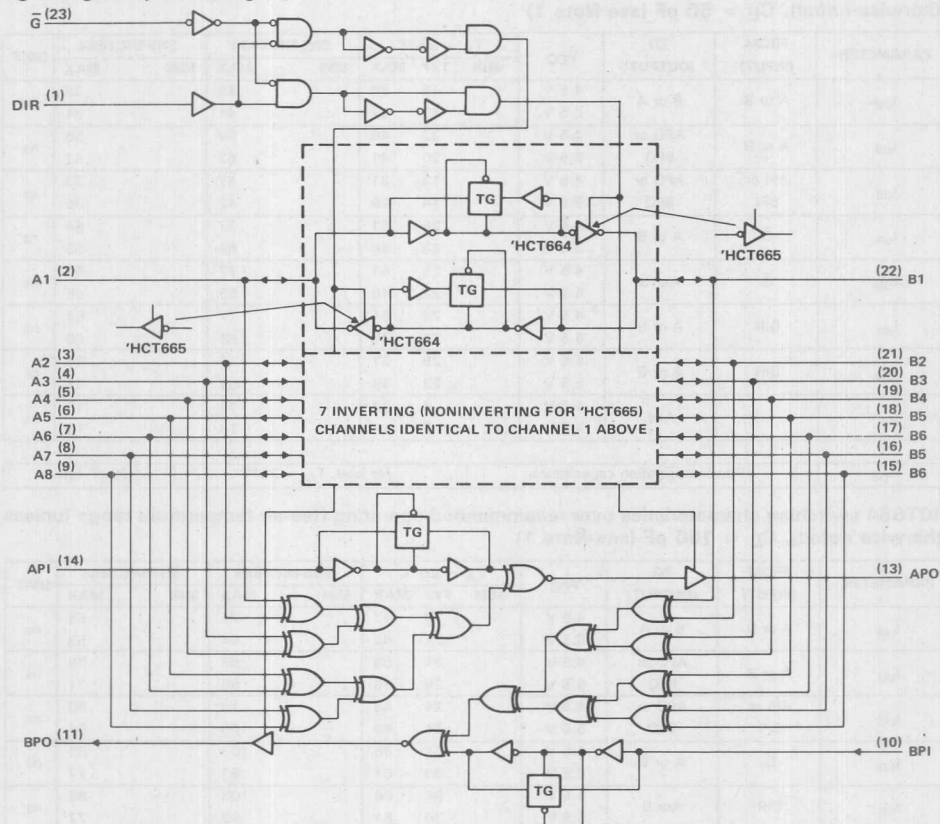


Pin numbers shown are for JT and NT packages.



# TYPES SN54HCT664, SN54HCT665, SN74HCT664, SN74HCT665 OCTAL BUS TRANSCEIVERS WITH PARITY

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

Because of the nature of the transceiver I/O ports and the parity inputs, the following additional parameter applies. It is the peak current as the input changes from 0 V to V<sub>CC</sub>.

PARAMETER	TEST CONDITION	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT664 SN54HCT665		SN74HCT664 SN74HCT665		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
I <sub>I/M</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub>	6 V			± 400		± 520		± 520	μA

# TYPES SN54HCT664, SN74HCT664, OCTAL BUS TRANSCEIVERS WITH PARITY

'HCT664 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT664		SN74HCT664		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		15	30		45		38	ns
			5.5 V		13	27		41		34	
$t_{pd}$	A or B	APO or BPO	4.5 V		23	46		69		58	ns
			5.5 V		20	41		62		52	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		15	31		47		39	ns
			5.5 V		14	28		42		35	
$t_{en}$	$\overline{G}$	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{dis}$	$\overline{G}$	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{en}$	DIR	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{dis}$	DIR	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_t$		Any	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	62 pF typ
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'HCT664 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT664		SN74HCT664		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		23	47		71		59	ns
			5.5 V		21	42		64		53	
$t_{pd}$	A or B	APO or BPO	4.5 V		31	63		95		79	ns
			5.5 V		28	56		85		71	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		24	48		73		60	ns
			5.5 V		21	43		65		54	
$t_{en}$	$\overline{G}$	A or B	4.5 V		34	68		103		85	ns
			5.5 V		30	61		92		77	
$t_{en}$	DIR	A or B	4.5 V		34	68		103		85	ns
			5.5 V		30	61		92		77	
$t_t$		Any	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

For typical application data and a description of the unique input structure, see the 'HC664 series data sheet.

**TYPES SN54HCT665, SN74HCT665**  
**OCTAL BUS TRANSCEIVERS WITH PARITY**

'HCT665 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT665		SN74HCT665		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		14	28		61		50	ns
			5.5 V		12	25		42		35	
$t_{pd}$	A or B	APO or BPO	4.5 V		23	46		69		58	ns
			5.5 V		20	41		62		52	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		15	31		47		39	ns
			5.5 V		14	28		42		35	
$t_{en}$	$\overline{G}$	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{dis}$	$\overline{G}$	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{en}$	DIR	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_{dis}$	DIR	A or B	4.5 V		25	51		77		64	ns
			5.5 V		23	46		69		58	
$t_t$		Any	4.5 V		8	12		18		15	ns
			5.5 V		7	11		16		14	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	62 pF typ
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'HCT665 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT665		SN74HCT665		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	B or A	4.5 V		22	45		84		69	ns
			5.5 V		20	40		68		56	
$t_{pd}$	A or B	APO or BPO	4.5 V		31	63		95		79	ns
			5.5 V		28	56		85		71	
$t_{pd}$	API or BPI	APO or BPO	4.5 V		24	48		73		60	ns
			5.5 V		21	43		65		54	
$t_{en}$	$\overline{G}$	A or B	4.5 V		34	68		103		85	ns
			5.5 V		30	61		92		77	
$t_{en}$	DIR	A or B	4.5 V		34	68		103		85	ns
			5.5 V		30	61		92		77	
$t_t$		Any	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

For typical application data and a description of the unique input structure, see the 'HC664 series data sheet.

# TYPE 5500 BUS TRANSCEIVER WITH PARITY OCTAL BUS TRANSCEIVER WITH PARITY

NOTES: 1. All timing characteristics are given at room temperature unless otherwise noted. 2.  $t_{pd}$  is the propagation delay time.

PARAMETER	UNIT	MIN.	TYP.	MAX.
Propagation delay, $t_{pd}$	ns	10	15	20
Setup time, $t_{su}$	ns	10	15	20
Hold time, $t_{h}$	ns	10	15	20
Output delay, $t_{od}$	ns	10	15	20
Input delay, $t_{id}$	ns	10	15	20
Output current, $I_{OL}$	mA	10	15	20
Input current, $I_{IH}$	mA	10	15	20
Power dissipation, $P_D$	mW	10	15	20
Supply current, $I_{CC}$	mA	10	15	20
Operating temperature range	°C	10	15	20

NOTES: 1. All timing characteristics are given at room temperature unless otherwise noted. 2.  $t_{pd}$  is the propagation delay time.

PARAMETER	UNIT	MIN.	TYP.	MAX.
Propagation delay, $t_{pd}$	ns	10	15	20
Setup time, $t_{su}$	ns	10	15	20
Hold time, $t_{h}$	ns	10	15	20
Output delay, $t_{od}$	ns	10	15	20
Input delay, $t_{id}$	ns	10	15	20
Output current, $I_{OL}$	mA	10	15	20
Input current, $I_{IH}$	mA	10	15	20
Power dissipation, $P_D$	mW	10	15	20
Supply current, $I_{CC}$	mA	10	15	20
Operating temperature range	°C	10	15	20

NOTES: 1. All timing characteristics are given at room temperature unless otherwise noted. 2.  $t_{pd}$  is the propagation delay time.

## 3 HCMOS DEVICES

- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

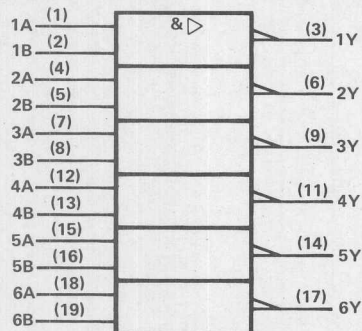
These devices contain six independent 2-input NAND drivers. They perform the Boolean functions  $Y = A \cdot B$  or  $Y = \overline{A + B}$  in positive logic.

The SN54HC804 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC804 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

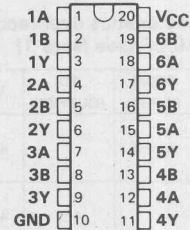
FUNCTION TABLE (each driver)

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

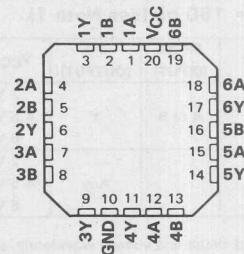
### logic symbol



SN54HC804 ... J PACKAGE  
SN74HC804 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC804 ... FH OR FK PACKAGE  
(TOP VIEW)



3

HCMOS DEVICES

# **TYPES SN54HC804, SN74HC804** **HEX 2-INPUT NAND DRIVERS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC804		SN74HC804		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		40	100		150		125	ns
			4.5 V		12	20		30		25	
			6 V		10	17		26		22	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C			40 pF typ		

3

HC MOS DEVICES

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC804		SN74HC804		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		60	185		280		230	ns
			4.5 V		20	37		56		46	
			6 V		16	32		48		41	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC805, SN74HC805 HEX 2-INPUT NOR DRIVERS

D2804, MARCH 1984

- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

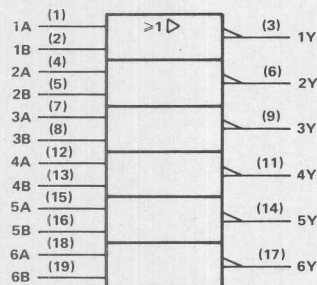
These devices contain six independent 2-input NOR drivers. They perform the Boolean functions  $Y = \overline{A+B}$  or  $Y = \overline{A \cdot B}$  in positive logic.

The SN54HC805 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC805 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

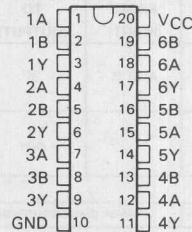
FUNCTION TABLE (each driver)

INPUTS		OUTPUT
A	B	Y
H	X	L
X	H	L
L	L	H

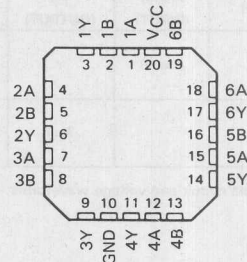
### logic symbol



SN54HC805...J PACKAGE  
SN74HC805...J OR NOR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC805...FH OR FK PACKAGE  
(TOP VIEW)



3

HCMOS DEVICES

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

# SN54HC805, SN74HC805 HEX 2-INPUT NOR DRIVERS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC805		SN74HC805		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		31	95		145		120	ns
			4.5 V		10	19		29		24	
			6 V		8	16		25		20	
$t_t$		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC805		SN74HC805		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		44	180		275		225	ns
			4.5 V		14	36		55		45	
			6 V		11	31		47		39	
$t_t$		Any	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC808, SN74HC808 HEX 2-INPUT AND DRIVERS

D2804, MARCH 1984

- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

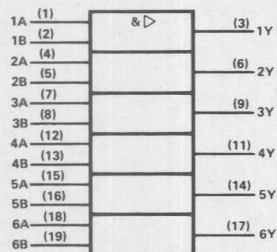
These devices contain six independent 2-input AND drivers. They perform the Boolean functions  $Y = A \cdot B$  or  $Y = \overline{A} + \overline{B}$  in positive logic.

The SN54HC808 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC808 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

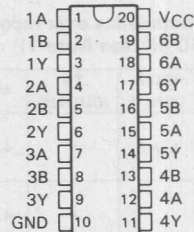
FUNCTION TABLE (each driver)

INPUTS		OUTPUT
A	B	Y
H	H	H
L	X	L
X	L	L

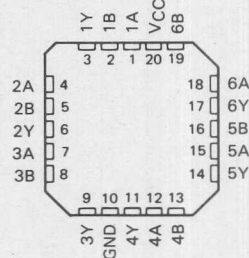
### logic symbol



SN54HC808 ... J PACKAGE  
SN74HC808 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC808 ... FH OR FK PACKAGE  
(TOP VIEW)



3

HCMOS DEVICES

**TYPES SN54HC808, SN74HC808**  
**HEX 2-INPUT AND DRIVERS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC808		SN74HC808		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
t <sub>t</sub>		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C			20 pF typ		

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC832, SN74HC832 HEX 2-INPUT OR DRIVERS

D2804, MARCH 1984

- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

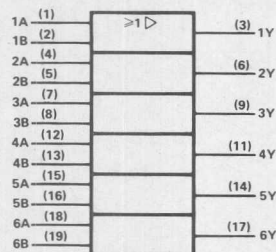
These devices contain six independent 2-input OR drivers. They perform the Boolean functions  $Y = A + B$  or  $Y = \overline{A \cdot B}$  in positive logic.

The SN54HC832 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC832 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

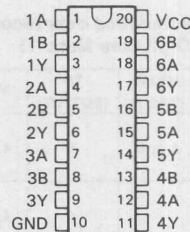
FUNCTION TABLE (each driver)

INPUTS		OUTPUT
A	B	Y
H	X	H
X	H	H
L	L	L

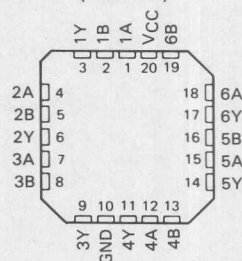
### logic symbol



SN54HC832... J PACKAGE  
SN74HC832... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC832... FH OR FK PACKAGE  
(TOP VIEW)



3

HCMOS DEVICES

# **TYPES SN54HC832, SN74HC832** **HEX 2-INPUT OR DRIVERS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC832		SN74HC832		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		50	100		150		125	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
t <sub>t</sub>		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C			20 pF typ		

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC4002, SN74HC4002 DUAL 4-INPUT POSITIVE-NOR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These devices contain two independent 4-input positive NOR gates. They perform the Boolean functions:

$$Y = A + B + C + D \text{ or } Y = \overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D}$$

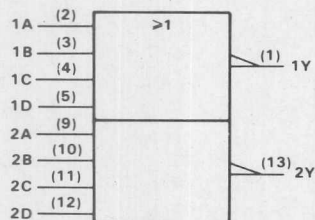
in positive logic.

The SN54HC4002 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4002 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

INPUTS				OUTPUT
A	B	C	D	Y
H	X	X	X	L
X	H	X	X	L
X	X	H	X	L
X	X	X	H	L
L	L	L	L	H

## logic symbol

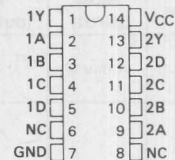


Pin numbers shown are for J and N packages.

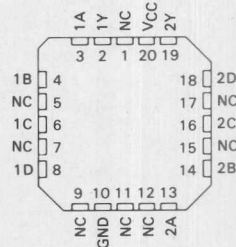
## maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

## SN54HC4002...J PACKAGE SN74HC4002...J OR N OR D (= SO) PACKAGE (TOP VIEW)



## SN54HC4002...FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

3

HCMOS DEVICES

# **TYPES SN54HC4002, SN74HC4002** **DUAL 4-INPUT POSITIVE-NOR GATES**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC4002		SN74HC4002		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A thru D	Y	2 V		44	110		165		140	ns
			4.5 V		12	22		33		28	
			6 V		11	19		28		24	
$t_t$		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

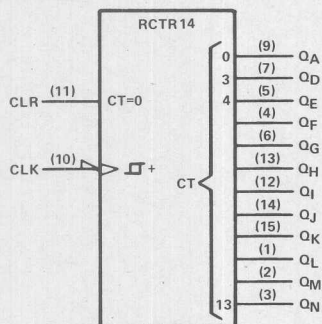
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

These devices are 14-stage binary ripple-carry counters that advance on the negative-going edge of the clock pulse. The counters are reset to zero (all outputs low) independently of the clock when CLR goes high.

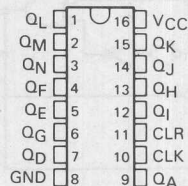
The SN54HC4020 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4020 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**logic symbol**

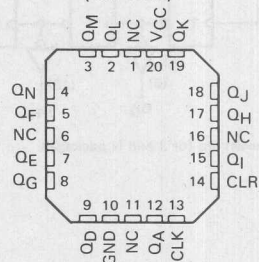


Pin numbers shown are for J and N packages.

**SN54HC4020 . . . J PACKAGE  
SN74HC4020 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



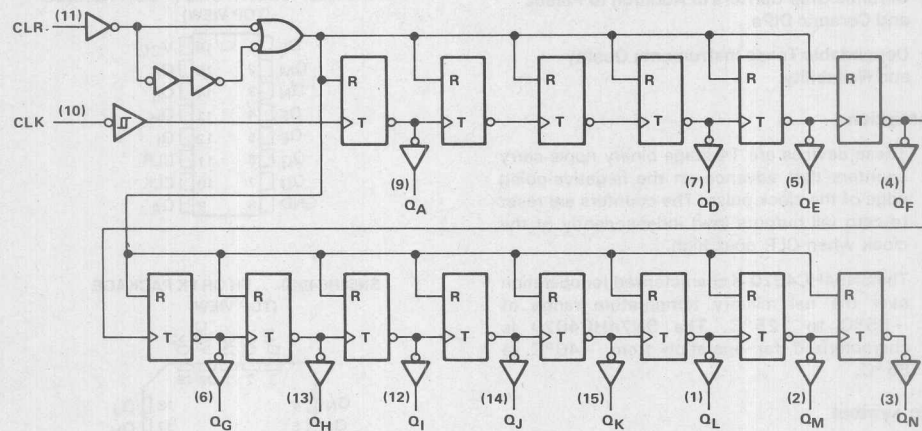
**SN54HC4020 . . . FH OR FK PACKAGE  
(TOP VIEW)**



NC—No internal connection

**TYPES SN54HC4020, SN74HC4020**  
**ASYNCHRONOUS 14-BIT BINARY COUNTERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4020		SN74HC4020		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		5.5	0	3.7	0	4.3	MHz
		4.5 V	0		28	0	19	0	22	
		6 V	0		33	0	22	0	25	
t <sub>w</sub>	Pulse duration	CLK high or low	2 V		90		135		115	ns
			4.5 V		18		27		23	
			6 V		15		23		20	
	CLR high		2 V		70		105		90	ns
			4.5 V		14		21		18	
			6 V		12		18		25	
t <sub>su</sub>	Setup time, CLR inactive before CLK↓	2 V			60		90		75	ns
		4.5 V			12		18		15	
		6 V			10		15		13	

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4020		SN74HC4020		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5.5	10		3.7		4.3		MHz
			4.5 V	28	45		19		22		
			6 V	33	53		22		25		
t <sub>pd</sub>	CLK	Q <sub>A</sub>	2 V		62	150		225		190	ns
			4.5 V		16	30		45		38	
			6 V		12	26		38		32	
t <sub>PHL</sub>	CLR	Any	2 V		63	140		210		175	ns
			4.5 V		17	28		42		35	
			6 V		13	24		36		30	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	88 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

Electrical characteristics are given for recommended operating conditions, and electrical characteristics

are given in Table 1.

Electrical characteristics are given for recommended operating conditions, and electrical characteristics

Symbol	Description	TA = 25°C		TA = 55°C		TA = 75°C	
		Min	Max	Min	Max	Min	Max
V <sub>DD</sub>	Supply Voltage	2.7	3.0	2.7	3.0	2.7	3.0
V <sub>SS</sub>	Ground Voltage	0	0	0	0	0	0
I <sub>DD</sub>	Supply Current	10	20	10	20	10	20
I <sub>SS</sub>	Ground Current	0	0	0	0	0	0
V <sub>OL</sub>	Output Low Voltage	0.1	0.1	0.1	0.1	0.1	0.1
V <sub>OH</sub>	Output High Voltage	2.4	2.4	2.4	2.4	2.4	2.4
t <sub>PLH</sub>	Propagation Delay Low to High	10	10	10	10	10	10
t <sub>PHL</sub>	Propagation Delay High to Low	10	10	10	10	10	10
t <sub>tr</sub>	Transition Time	10	10	10	10	10	10
t <sub>su</sub>	Setup Time	10	10	10	10	10	10
t <sub>ho</sub>	Hold Time	10	10	10	10	10	10

Electrical characteristics are given for recommended operating conditions, and electrical characteristics

Symbol	Description	TA = 25°C		TA = 55°C		TA = 75°C	
		Min	Max	Min	Max	Min	Max
V <sub>DD</sub>	Supply Voltage	2.7	3.0	2.7	3.0	2.7	3.0
V <sub>SS</sub>	Ground Voltage	0	0	0	0	0	0
I <sub>DD</sub>	Supply Current	10	20	10	20	10	20
I <sub>SS</sub>	Ground Current	0	0	0	0	0	0
V <sub>OL</sub>	Output Low Voltage	0.1	0.1	0.1	0.1	0.1	0.1
V <sub>OH</sub>	Output High Voltage	2.4	2.4	2.4	2.4	2.4	2.4
t <sub>PLH</sub>	Propagation Delay Low to High	10	10	10	10	10	10
t <sub>PHL</sub>	Propagation Delay High to Low	10	10	10	10	10	10
t <sub>tr</sub>	Transition Time	10	10	10	10	10	10
t <sub>su</sub>	Setup Time	10	10	10	10	10	10
t <sub>ho</sub>	Hold Time	10	10	10	10	10	10

Electrical characteristics are given for recommended operating conditions, and electrical characteristics

Electrical characteristics are given for recommended operating conditions, and electrical characteristics

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4024, SN74HC4024 ASYNCHRONOUS 7-BIT BINARY COUNTERS

D2804, MARCH 1984

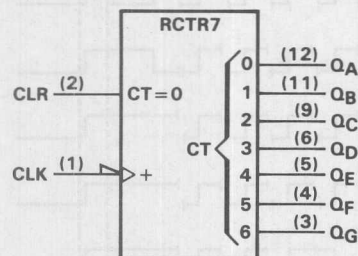
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC4024 is an asynchronous 7-stage binary counter designed with an input pulse-shaping circuit. The outputs of all stages are available externally. A high clear signal asynchronously clears the counter and resets all outputs low. The count is advanced on the high-to-low transition of the clock pulse. Applications include time-delay circuits, counter controls, and frequency-dividing circuits.

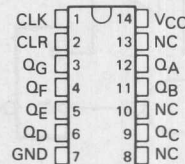
The SN54HC4024 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4024 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

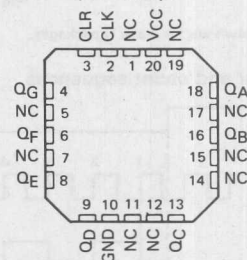


Pin numbers shown are for J and N packages.

### SN54HC4024 ... J PACKAGE SN74HC4024 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC4024 ... FH OR FK PACKAGE (TOP VIEW)



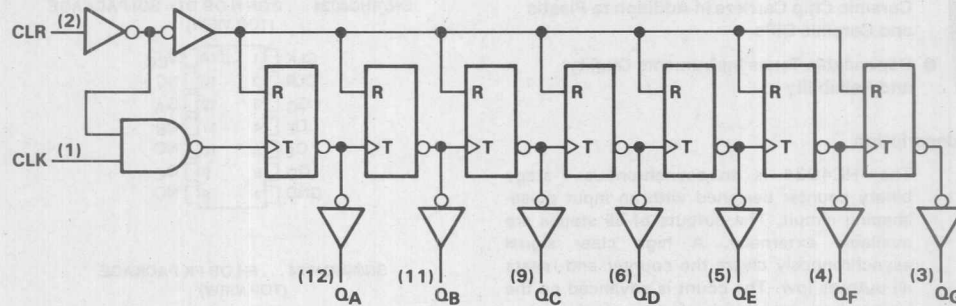
NC—No internal connection.

3

HC MOS DEVICES

# TYPES SN54HC4024, SN74HC4024 ASYNCHRONOUS 7-BIT BINARY COUNTERS

logic diagram (positive logic)

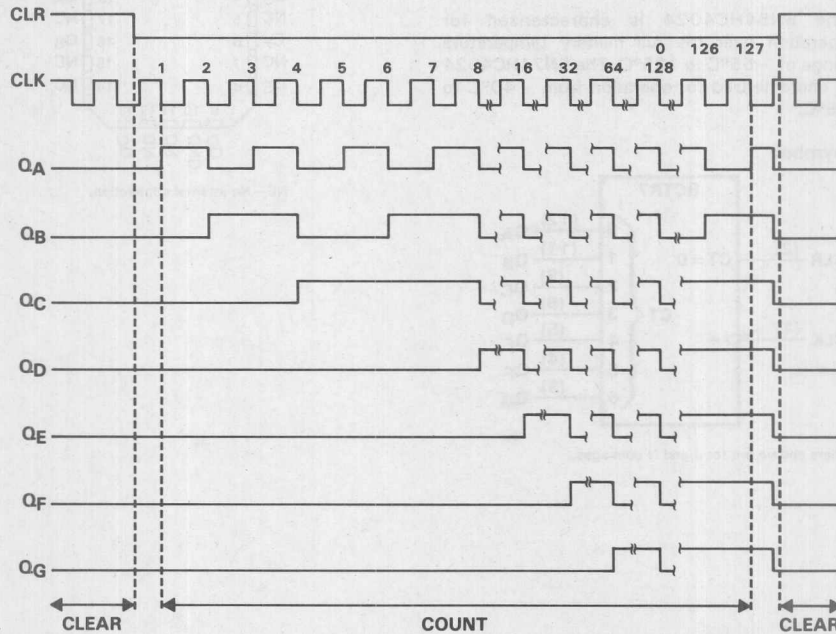


Pin numbers shown are for J and N packages.

3

HCMOS DEVICES

typical clear and count sequences



# TYPES SN54HC4024, SN74HC4024 ASYNCHRONOUS 7-BIT BINARY COUNTERS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4024		SN74HC4024		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		5.5	0	3.7	0	4.3	MHz
		4.5 V	0		28	0	19	0	22	
		6 V	0		33	0	22	0	25	
t <sub>w</sub>	Pulse duration	2 V	90			135		115		ns
		4.5 V	18			27		23		
		6 V	15			23		20		
	CLR high	2 V	80			120		100		
		4.5 V	16			24		20		
		6 V	14			20		17		
t <sub>su</sub>	Setup time, CLR low before CLK ↓	2 V	80			120		100		ns
		4.5 V	16			24		20		
		6 V	14			20		17		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4024		SN74HC4024		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5.5	10		3.7		4.3		MHz
			4.5 V	28	50		19		22		
			6 V	33	60		22		26		
t <sub>pd</sub>	CLK	Q <sub>A</sub>	2 V		56	120		180		150	ns
			4.5 V		16	24		36		30	
			6 V		12	20		31		26	
t <sub>PHL</sub>	CLR	Any	2 V		61	130		195		165	ns
			4.5 V		17	26		39		33	
			6 V		13	22		33		28	
t <sub>t</sub>			2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance					No load, T <sub>A</sub> = 25 °C		40 pF typ			

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HC MOS DEVICES



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4040, SN74HC4040 ASYNCHRONOUS 12-BIT BINARY COUNTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

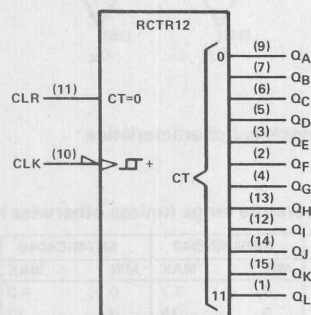
- Dependable Texas Instruments Quality and Reliability

### description

This device is an asynchronous 12-state binary counter with the outputs of all stages available externally. A high level at CLR asynchronously clears the counter and resets all outputs low. The count is advanced on a high-to-low transition at CLK. Applications include time delay circuits, counter controls, and frequency-dividing circuits.

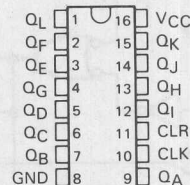
The SN54HC4040 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4040 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

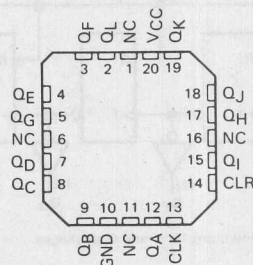


Pin numbers shown are for J and N packages.

### SN54HC4040 . . . J PACKAGE SN74HC4040 . . . J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC4040 . . . FH OR FK PACKAGE (TOP VIEW)



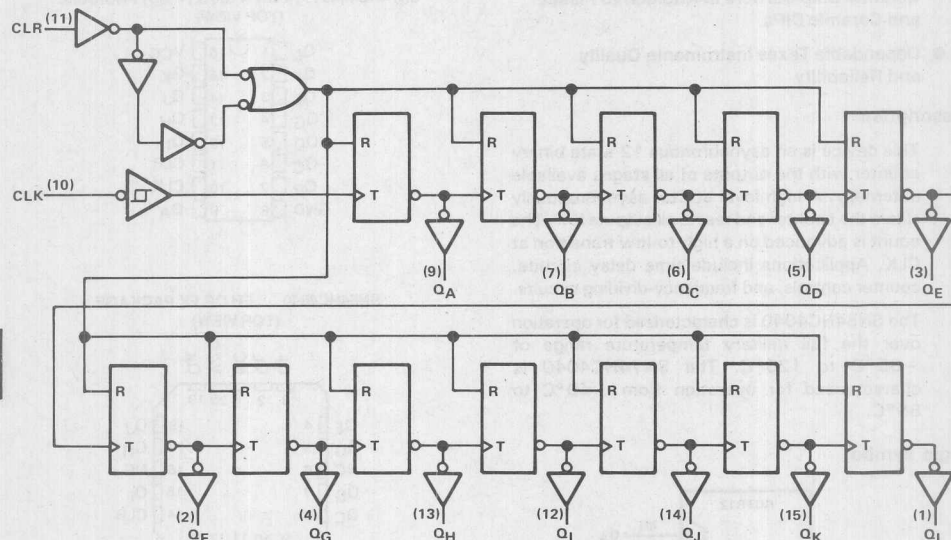
NC—No internal connection

3

HCMOS DEVICES

# **TYPES SN54HC4040, SN74HC4040** **ASYNCHRONOUS 12-BIT BINARY COUNTERS**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

## **maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

## **timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC4040		SN74HC4040		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency		2 V	0	5.5	0	3.7	0	4.3	MHz
		4.5 V	0	28	0	19	0	22	
		6 V	0	33	0	22	0	25	
t <sub>w</sub> Pulse duration	CLK high or low	2 V	90		135		115	ns	
		4.5 V	18		27		23		
		6 V	15		23		20		
	CLR high	2 V	70		105		90	ns	
		4.5 V	14		21		18		
		6 V	12		18		15		
t <sub>su</sub> Setup time, CLR inactive before CLK ↓		2 V	60		90		75	ns	
		4.5 V	12		18		15		
		6 V	10		15		13		



switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC4040		SN74HC4040		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	5.5	10		3.7		4.3		MHz
			4.5 V	28	45		19		22		
			6 V	33	53		22		25		
$t_{\text{pd}}$	CLK	$Q_A$	2 V		62	150		225		190	ns
			4.5 V		16	30		45		38	
			6 V		12	26		38		32	
$t_{\text{PHL}}$	CLR	Any	2 V		63	140		210		175	ns
			4.5 V		17	28		42		35	
			6 V		13	24		36		30	
$t_t$		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	30		19		16	

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	88 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

3

HCMOS DEVICES

# 3

## HCMOS DEVICES

# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC4060, SN74HC4060 ASYNCHRONOUS 14-STAGE BINARY COUNTERS AND OSCILLATORS**

D2684, DECEMBER 1982—REVISED MARCH 1984

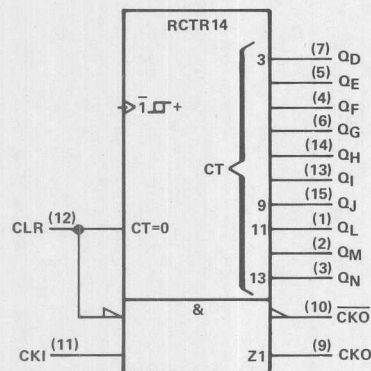
- Allows Design of Either RC or Crystal Oscillator Circuits
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### **description**

The 'HC4060 consists of an oscillator section and 14 ripple-carry binary counter stages. The oscillator configuration allows design of either RC or crystal oscillator circuits. A high-to-low transition on the clock input increments the counter. A high level at CLR disables the oscillator (CKO goes high and CKO goes low) and resets the counter to zero (all Q outputs low).

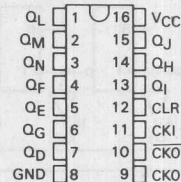
The SN54HC4060 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4060 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### **logic symbol**

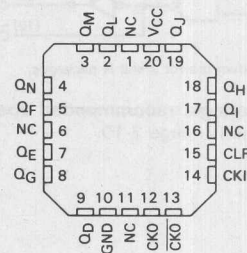


Pin numbers shown are for J and N packages.

### **SN54HC4060 . . . J PACKAGE SN74HC4060 . . . J OR N OR D (= SO) PACKAGE (TOP VIEW)**



### **SN54HC4060 . . . FH OR FK PACKAGE (TOP VIEW)**



NC—No internal connection

3

HCMOS DEVICES

3



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

# **TYPES SN54HC4060, SN74HC4060** **ASYNCHRONOUS 14-STAGE BINARY COUNTERS** **AND OSCILLATORS**

**timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC4060		SN74HC4060		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5.5	0	3.7	0	4.3	MHz
		4.5 V	0	28	0	19	0	22	
		6 V	0	33	0	22	0	25	
t <sub>w</sub>	Pulse duration	CKI high or low	2 V	90	135		115		ns
			4.5 V	18	27		23		
			6 V	15	23		20		
	CLR high		2 V	90	135		115		ns
			4.5 V	18	27		23		
			6 V	15	23		20		
t <sub>su</sub>	Setup time, CLR inactive before CKI ↓	2 V	160		240		200		ns
		4.5 V	32		48		40		
		6 V	27		41		34		

**switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC4060		SN74HC4060		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5.5	10		3.7		4.3		MHz
			4.5 V	28	45		19		22		
			6 V	33	53		22		25		
t <sub>pd</sub>	CKI	Q <sub>D</sub>	2 V		240	490		735		615	ns
			4.5 V		58	98		147		123	
			6 V		42	83		125		105	
t <sub>PHL</sub>	CLR	Any Q	2 V		66	140		210		175	ns
			4.5 V		18	28		42		35	
			6 V		14	24		36		30	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	88 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**3**

**HCMOS DEVICES**

# ASYNCHRONOUS 14-STAGE BINARY COUNTERS AND OSCILLATORS

Operating temperature range: -55°C to +125°C (unless otherwise noted)

UNIT	MAXIMUM		TYPICAL		MINIMUM		UNIT
	MAX	MIN	MAX	MIN	MAX	MIN	
Supply Voltage	5.0	4.5	5.0	4.5	5.0	4.5	V <sub>CC</sub>
	5.0	4.5	5.0	4.5	5.0	4.5	
Operating Frequency	100	10	100	10	100	10	kHz
	100	10	100	10	100	10	
Propagation Delay	10	1	10	1	10	1	ns
	10	1	10	1	10	1	
Setup Time	10	1	10	1	10	1	ns
	10	1	10	1	10	1	
Hold Time	10	1	10	1	10	1	ns
	10	1	10	1	10	1	

Operating frequency and setup time are recommended operating limits at temperature range limits unless noted. C<sub>L</sub> = 50 pF unless noted.

UNIT	MAXIMUM		TYPICAL		MINIMUM		UNIT
	MAX	MIN	MAX	MIN	MAX	MIN	
Supply Voltage	5.0	4.5	5.0	4.5	5.0	4.5	V <sub>CC</sub>
	5.0	4.5	5.0	4.5	5.0	4.5	
Operating Frequency	100	10	100	10	100	10	kHz
	100	10	100	10	100	10	
Propagation Delay	10	1	10	1	10	1	ns
	10	1	10	1	10	1	
Setup Time	10	1	10	1	10	1	ns
	10	1	10	1	10	1	
Hold Time	10	1	10	1	10	1	ns
	10	1	10	1	10	1	

Operating frequency and setup time are recommended operating limits at temperature range limits unless noted. C<sub>L</sub> = 50 pF unless noted.

3

HCMOS DEVICES



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4061, SN74HC4061 ASYNCHRONOUS 14-STAGE BINARY COUNTERS AND OSCILLATORS

D2804, MARCH 1984

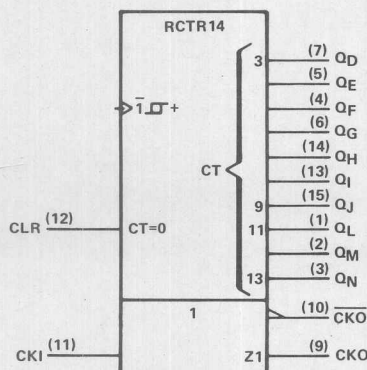
- Allows Design of Either RC or Crystal Oscillator Circuits
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC4061 consists of an oscillator section and 14 ripple-carry binary counter stages. The oscillator configuration allows design of either RC or crystal oscillator circuits. A high-to-low transition on the clock input increments the counter. A high level at CLR resets the counter to zero (all Q outputs low) but has no effect on the oscillator.

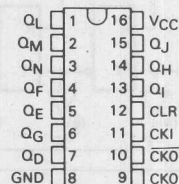
The SN54HC4061 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4061 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

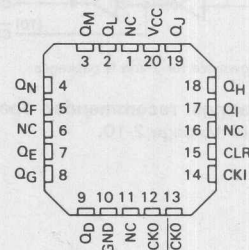


Pin numbers shown are for J and N packages.

SN54HC4061...J PACKAGE  
SN74HC4061...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC4061...FH OR FK PACKAGE  
(TOP VIEW)



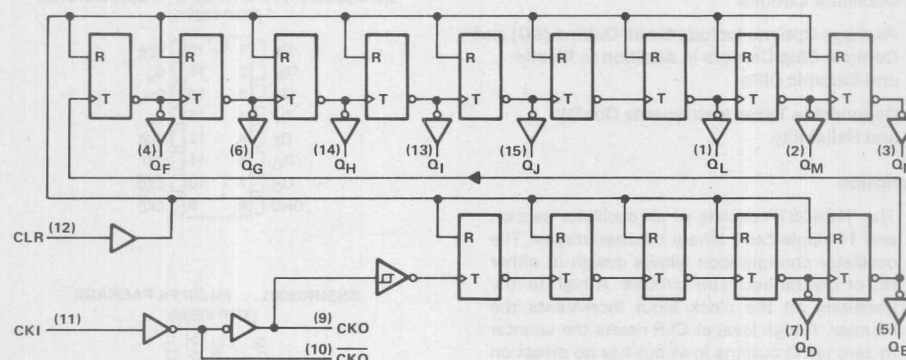
NC—No internal connection

3

HCMOS DEVICES

**TYPES SN54HC4061, SN74HC4061**  
**ASYNCHRONOUS 14-STAGE BINARY COUNTERS**  
**AND OSCILLATORS**

logic diagram (positive logic)



3

Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

HC MOS DEVICES

# **TYPES SN54HC4061, SN74HC4061** **ASYNCHRONOUS 14-STAGE BINARY COUNTERS** **AND OSCILLATORS**

**timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC4061		SN74HC4061		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V		5.5		3.7		4.3	MHz
		4.5 V		28		19		22	
		6 V		33		22		25	
t <sub>w</sub>	Pulse duration	CKI high or low	2 V	90	135		115		ns
			4.5 V	18	27		23		
			6 V	15	23		20		
	CLR high		2 V	90	135		115		ns
			4.5 V	18	27		23		
			6 V	15	23		20		
t <sub>su</sub>	Setup time, CLR inactive before CKI↓	2 V	160		240		200		ns
		4.5 V	32		48		40		
		6 V	27		41		34		

**switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4061		SN74HC4061		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5.5	10		3.7		4.3		MHz
			4.5 V	28	45		19		22		
			6 V	33	53		22		25		
t <sub>pd</sub>	CKI	Q <sub>D</sub>	2 V		240	490		735		615	ns
			4.5 V		58	98		147		123	
			6 V		42	83		125		105	
t <sub>PHL</sub>	CLR	Any Q	2 V		66	140		210		175	ns
			4.5 V		18	28		42		35	
			6 V		14	24		36		30	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	88 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

**3**

**HCMOS DEVICES**



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4075, SN74HC4075 TRIPLE 3-INPUT OR GATES

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

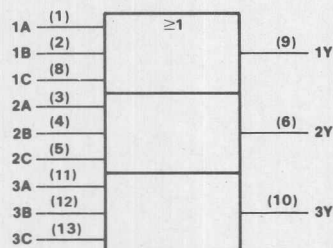
- Dependable Texas Instruments Quality and Reliability

### description

These devices contain three independent 3-input OR gates and perform the Boolean functions  $Y = A + B + C$  or  $Y = \bar{A} \cdot \bar{B} \cdot \bar{C}$  in positive logic.

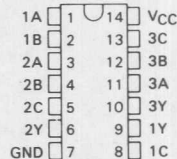
The SN54HC4075 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4075 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

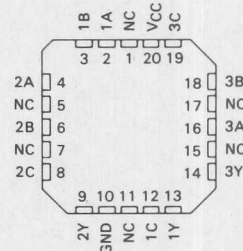


Pin numbers shown are for J and N packages.

### SN54HC4075... J PACKAGE SN74HC4075... J OR N OR D (= SO) PACKAGE (TOP VIEW)



### SN54HC4075... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

### FUNCTION TABLE

INPUTS			OUTPUT
A	B	C	Y
H	X	X	H
X	H	X	H
X	X	H	H
L	L	L	L

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4075		SN74HC4075		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A, B, or C	Y	2 V		38	100		150		125	ns
			4.5 V		11	20		30		25	
			6 V		9	17		25		21	
t <sub>t</sub>		Y	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	
C <sub>pd</sub>	Power dissipation capacitance per gate					No load, T <sub>A</sub> = 25°C				26 pF	typ

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

TEXAS  
INSTRUMENTS

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HCMOS DEVICES

## TYPICAL CHARACTERISTICS

TEMPERATURE RANGE: -40°C TO +125°C

WARRANTY: 1 YEAR (SEE PAGE 10)

PARAMETER	UNIT	MIN.	TYP.	MAX.
$V_{DD}$	V	2.0	2.5	3.0
$V_{SS}$	V	0.0	0.0	0.0
$V_{OL}$	V	0.0	0.0	0.0
$V_{OH}$	V	2.0	2.5	3.0
$V_{IL}$	V	0.8	1.0	1.2
$V_{IH}$	V	1.8	2.0	2.2
$V_{T}$	V	0.5	0.7	0.9
$V_{T}$	V	0.5	0.7	0.9

WARRANTY: 1 YEAR (SEE PAGE 10)

PARAMETER	UNIT	MIN.	TYP.	MAX.
$V_{DD}$	V	2.0	2.5	3.0
$V_{SS}$	V	0.0	0.0	0.0
$V_{OL}$	V	0.0	0.0	0.0
$V_{OH}$	V	2.0	2.5	3.0
$V_{IL}$	V	0.8	1.0	1.2
$V_{IH}$	V	1.8	2.0	2.2
$V_{T}$	V	0.5	0.7	0.9
$V_{T}$	V	0.5	0.7	0.9

WARRANTY: 1 YEAR (SEE PAGE 10)

PARAMETER	UNIT	MIN.	TYP.	MAX.
$V_{DD}$	V	2.0	2.5	3.0
$V_{SS}$	V	0.0	0.0	0.0
$V_{OL}$	V	0.0	0.0	0.0
$V_{OH}$	V	2.0	2.5	3.0
$V_{IL}$	V	0.8	1.0	1.2
$V_{IH}$	V	1.8	2.0	2.2
$V_{T}$	V	0.5	0.7	0.9
$V_{T}$	V	0.5	0.7	0.9

WARRANTY: 1 YEAR (SEE PAGE 10)

WARRANTY: 1 YEAR (SEE PAGE 10)

WARRANTY: 1 YEAR (SEE PAGE 10)

PARAMETER	UNIT	MIN.	TYP.	MAX.
$V_{DD}$	V	2.0	2.5	3.0
$V_{SS}$	V	0.0	0.0	0.0
$V_{OL}$	V	0.0	0.0	0.0
$V_{OH}$	V	2.0	2.5	3.0
$V_{IL}$	V	0.8	1.0	1.2
$V_{IH}$	V	1.8	2.0	2.2
$V_{T}$	V	0.5	0.7	0.9
$V_{T}$	V	0.5	0.7	0.9

WARRANTY: 1 YEAR (SEE PAGE 10)	WARRANTY: 1 YEAR (SEE PAGE 10)	WARRANTY: 1 YEAR (SEE PAGE 10)
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WARRANTY: 1 YEAR (SEE PAGE 10)



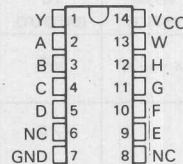
# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4078A, SN74HC4078A 8-INPUT OR/NOR GATE

D2804, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC4078A ... J PACKAGE  
SN74HC4078A ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



### description

These devices contain a single 8-input OR/NOR gate and perform the following Boolean functions in positive logic:

$$W = A + B + C + D + E + F + G + H$$

or

$$W = \overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} \cdot \overline{E} \cdot \overline{F} \cdot \overline{G} \cdot \overline{H}$$

and

$$Y = A + B + C + D + E + F + G + H$$

or

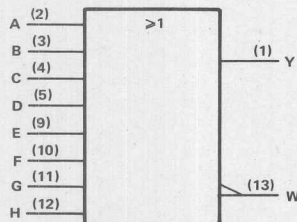
$$Y = \overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D} \cdot \overline{E} \cdot \overline{F} \cdot \overline{G} \cdot \overline{H}$$

The SN54HC4078A is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4078A is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

INPUTS A THRU H	OUTPUTS	
	W	Y
One or more inputs H	L	H
All inputs L	H	L

### logic symbol

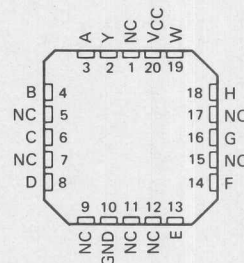


Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

SN54HC4078A ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

3

HC MOS DEVICES

# **TYPES SN54HC4078A, SN74HC4078A** **8-INPUT OR/NOR GATE**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC4078A		SN74HC4078A		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A thru H	$Y/\bar{Y}$	2 V		40	130		195		165	ns
			4.5 V		12	26		39		33	
			6 V		10	22		33		28	
$t_t$		$Y/\bar{Y}$	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^\circ\text{C}$	25 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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HCMOS DEVICES

- 8-Bit-Parallel-Out Storage Register Performs Serial-to-Parallel Conversion with Storage
- Asynchronous Parallel Clear
- Active-High Decoder
- Enable Input Simplifies Expansion
- Expandable for N-Bit Applications
- Four Distinct Functional Modes
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

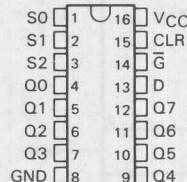
### description

These 8-bit addressable latches are designed for general purpose storage applications in digital systems. Specific uses include working registers, serial-holding registers, and active-high decoders or demultiplexers. They are multifunctional devices capable of storing single-line data in eight addressable latches, and being a 1-of-8 decoder or demultiplexer with active-high outputs.

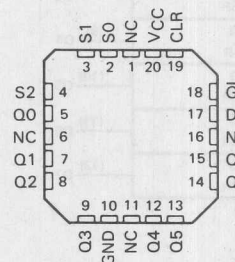
Four distinct modes of operation are selectable by controlling the clear (CLR) and enable ( $\bar{G}$ ) inputs as enumerated in the function table. In the addressable-latch mode, data at the data-in terminal is written into the addressed latch. The addressed latch will follow the data input with all unaddressed latches remaining in their previous states. In the memory mode, all latches remain in their previous states and are unaffected by the data or address inputs. To eliminate the possibility of entering erroneous data in the latches, enable  $\bar{G}$  should be held high (inactive) while the address lines are changing. In the 1-of-8 decoding or demultiplexing mode, the addressed output will follow the level of the D input with all other outputs low. In the clear mode, all outputs are low and unaffected by the address and data inputs.

The SN54HC4724 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4724 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC4724 . . . J PACKAGE  
SN74HC4724 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC4724 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE

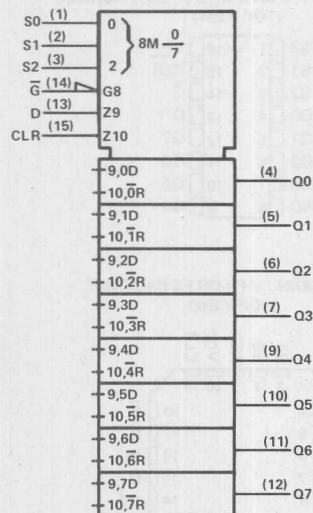
INPUTS		OUTPUT OF ADDRESSED LATCH	EACH OTHER OUTPUT	FUNCTION
CLR	$\bar{G}$			
L	L	D	$Q_iO$	Addressable Latch
L	H	$Q_iO$	$Q_iO$	Memory
H	L	D	L	8-Line Demultiplexer
H	H	L	L	Clear

LATCH SELECTION TABLE

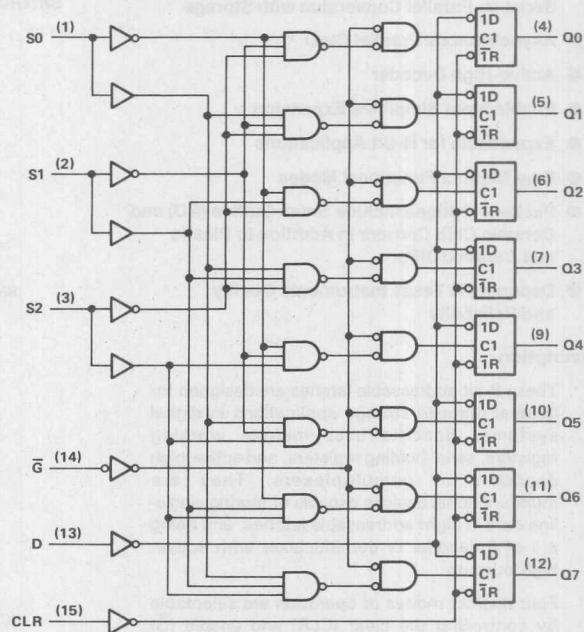
SELECT INPUTS			LATCH ADDRESSED
S2	S1	S0	
L	L	L	0
L	L	H	1
L	H	L	2
L	H	H	3
H	L	L	4
H	L	H	5
H	H	L	6
H	H	H	7

# TYPES SN54HC4724, SN74HC4724 8-BIT ADDRESSABLE LATCHES

logic symbol

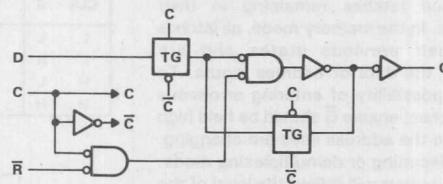
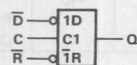


logic diagram (positive logic)



Pin numbers shown are for J and N packages.

logic symbol and logic diagram, each internal latch (positive logic)



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HC MOS DEVICES

# TYPES SN54HC4724, SN74HC4724 8-BIT ADDRESSABLE LATCHES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC4724		SN74HC4724		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub>	Pulse duration	CLR high	2 V	80	120	100	ns		
			4.5 V	16	24	20			
			6 V	14	20	17			
	$\overline{G}$ low		2 V	80	120	100			
			4.5 V	16	24	20			
			6 V	14	20	17			
t <sub>su</sub>	Setup time, data or address before $\overline{G}$ ↑	2 V	75	115	95	ns			
		4.5 V	15	23	19				
		6 V	13	20	16				
t <sub>h</sub>	Hold time, data or address after $\overline{G}$ ↑	2 V	5	5	5	ns			
		4.5 V	5	5	5				
		6 V	5	5	5				

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4724		SN74HC4724		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>PHL</sub>	CLR	Any Q	2 V		60	150		225		190	ns
			4.5 V		18	30		45		38	
			6 V		14	26		38		32	
t <sub>pd</sub>	Data	Any Q	2 V		56	130		195		165	ns
			4.5 V		17	26		39		33	
			6 V		13	22		33		28	
t <sub>pd</sub>	Address	Any Q	2 V		74	200		300		250	ns
			4.5 V		21	40		60		50	
			6 V		17	34		51		43	
t <sub>pd</sub>	$\bar{G}$	Any Q	2 V		66	170		255		215	ns
			4.5 V		20	34		51		43	
			6 V		16	29		43		37	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	33 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

MAXIMUM VOLTAGE, CURRENT, AND POWER RATING

See Table 1, Page 3-418

MAXIMUM VOLTAGE, CURRENT, AND POWER RATING

MAXIMUM VOLTAGE (V)	MAXIMUM CURRENT (A)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10

3

HCMOS DEVICES

MAXIMUM VOLTAGE, CURRENT, AND POWER RATING

MAXIMUM VOLTAGE (V)	MAXIMUM CURRENT (A)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)	MAXIMUM POWER (W)
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10

MAXIMUM VOLTAGE, CURRENT, AND POWER RATING

See Table 1, Page 3-418



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC7266, SN74HC7266 QUADRUPLE 2-INPUT EXCLUSIVE-NOR GATES

D2804, MARCH 1984

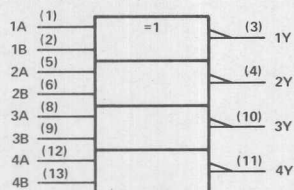
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices are composed of four independent 2-input exclusive-NOR gates. 'HC7266 devices are totem-pole-output versions of the 'HC266. They perform the Boolean functions  $Y = A \oplus B = \bar{A}B + A\bar{B}$  in positive logic.

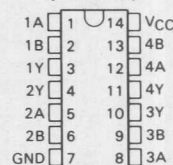
The SN54HC7266 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7266 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

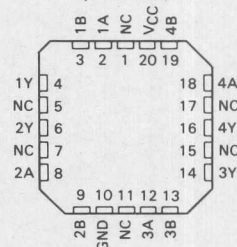


Pin numbers shown are for J and N packages.

SN54HC7266... J PACKAGE  
SN74HC7266... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7266... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

FUNCTION TABLE

INPUTS		OUTPUT
A	B	Y
L	L	H
L	H	L
H	L	L
H	H	H

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^{\circ}\text{C}$			SN54HC7266		SN74HC7266		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40	100		150		125	ns
			4.5 V		12	20		30		25	
			6 V		10	17		25		21	
$t_t$		Y	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

$C_{pd}$	Power dissipation capacitance per gate	No load, $T_A = 25^{\circ}\text{C}$	35 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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NOTES: 1. For more information, see page 3-10.

2. For more information, see page 3-10.

3. For more information, see page 3-10.

4. For more information, see page 3-10.

5. For more information, see page 3-10.

6. For more information, see page 3-10.

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39. For more information, see page 3-10.

40. For more information, see page 3-10.

41. For more information, see page 3-10.

42. For more information, see page 3-10.

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**GENERAL INFORMATION**

**1**

**RATINGS AND CHARACTERISTICS**

**2**

**HCMOS DEVICES**

**3**

**HCMOS DEVICES — ADVANCE INFORMATION**

**4**

**HCMOS DEVICES — PRODUCT PREVIEWS**

**5**

**EXPLANATION OF LOGIC SYMBOLS**

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**MECHANICAL DATA**

**8**

**QUALITY AND RELIABILITY**

**9**

## 4

### ADVANCE INFORMATION

#### ADVANCE INFORMATION

This section contains information on new products in the sampling or preproduction stage. Characteristic data and other specifications are subject to change without notice.

# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC73, SN74HC73 DUAL J-K FLIP-FLOPS WITH CLEAR

D2684, DECEMBER 1982—REVISED MARCH 1984

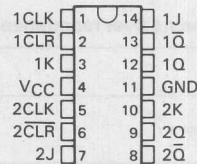
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the Clear input resets the outputs regardless of the other inputs. When Clear is inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These flip-flops can perform as toggle flip-flops by tying J and K high.

The SN54HC73 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC73 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC73... J PACKAGE  
SN74HC73... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

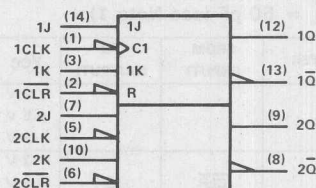


For functionally and electrically identical parts in chip carrier packages, see SN54HC107 and SN74HC107.

FUNCTION TABLE  
(EACH FLIP-FLOP)

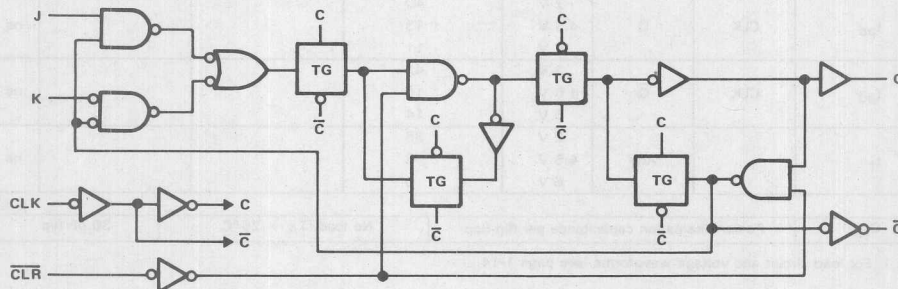
INPUTS				OUTPUTS	
CLR	CLK	J	K	Q	$\bar{Q}$
L	X	X	X	L	H
H	$\downarrow$	L	L	$Q_0$	$\bar{Q}_0$
H	$\downarrow$	H	L	H	L
H	$\downarrow$	L	H	L	H
H	$\downarrow$	H	H	TOGGLE	
H	H	X	X	$Q_0$	$\bar{Q}_0$

## logic symbol



Pin numbers shown are for J and N packages.

## logic diagram, each flip-flop (positive logic)



ADVANCE INFORMATION  
This document contains information on a new product. Specifications are subject to change without notice.

TEXAS  
INSTRUMENTS

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# **TYPES SN54HC73, SN74HC73** **DUAL J-K FLOP-FLOPS WITH CLEAR**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC73		SN74HC73		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5					MHz
		4.5 V	0	25					
		6 V	0	29					
t <sub>w</sub>	Pulse duration	2 V	100						ns
		4.5 V	20						
		6 V	17						
	CLR low	2 V	100						ns
		4.5 V	20						
		6 V	17						
t <sub>su</sub>	Setup time, CLR inactive or data before CLK↓	2 V	100						ns
		4.5 V	20						
		6 V	17						
t <sub>h</sub>	Hold time, data after CLK↓	2 V	0						ns
		4.5 V	0						
		6 V	0						

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC73		SN74HC73		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	9						MHz
			4.5 V	25	50						
			6 V	29	60						
t <sub>PHL</sub>	CLR	Q	2 V		42						ns
			4.5 V		16						
			6 V		14						
t <sub>PLH</sub>	CLR	Q̄	2 V		35						ns
			4.5 V		11						
			6 V		9						
t <sub>pd</sub>	CLK	Q	2 V		40						ns
			4.5 V		13						
			6 V		11						
t <sub>pd</sub>	CLK	Q̄	2 V		42						ns
			4.5 V		16						
			6 V		14						
t <sub>t</sub>		Any	2 V		38						ns
			4.5 V		8						
			6 V		6						

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25°C	30 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC78, SN74HC78 DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET, COMMON CLEAR, AND COMMON CLOCK

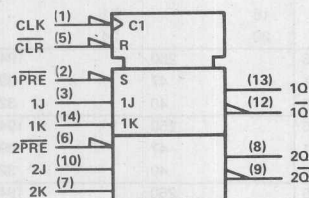
D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

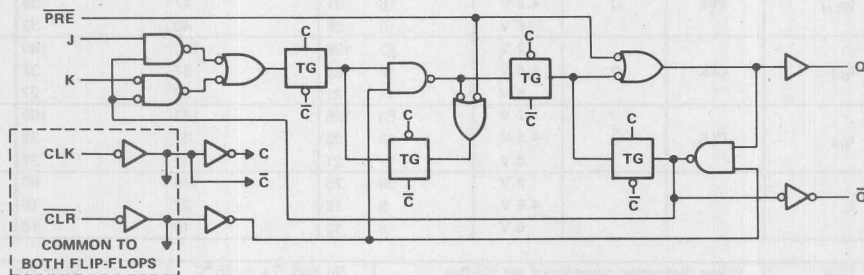
These devices contain two independent J-K negative-edge-triggered flip-flops. A low level at the Preset or Clear inputs sets or resets the outputs regardless of the levels of the other inputs. When the Preset and Clear are inactive (high), data at the J and K inputs meeting the setup time requirements are transferred to the outputs on the negative-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the J and K inputs may be changed without affecting the levels at the outputs. These versatile flip-flops can perform as toggle flip-flops by tying J and K high.

### logic symbol



Pin numbers shown are for J and N packages.

### logic diagram, each flip-flop (positive logic)



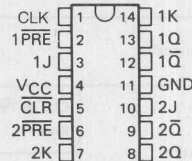
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table II, page 2-6.

ADVANCE INFORMATION  
This document contains information  
on a new product. Specifications are  
subject to change without notice.

TEXAS  
INSTRUMENTS

### SN54HC78 ... J PACKAGE SN74HC78 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



For functionally and electrically identical parts in chip carrier packages, see SN54HC114 and SN74HC114.

### FUNCTION TABLE

INPUTS					OUTPUTS	
PRE	CLR	CLK	J	K	Q	Q̄
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	↓	L	L	Q <sub>0</sub>	Q̄ <sub>0</sub>
H	H	↓	H	L	H	L
H	H	↓	L	H	L	H
H	H	↓	H	H	TOGGLE	TOGGLE
H	H	H	X	X	Q <sub>0</sub>	Q̄ <sub>0</sub>

\* This configuration is nonstable; that is, it will not persist when either Preset or Clear returns to its inactive (high) level.

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ADVANCE INFORMATION

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**TYPES SN54HC78, SN74HC78**  
**DUAL J-K NEGATIVE-EDGE-TRIGGERED FLIP-FLOPS**  
**WITH PRESET, COMMON CLEAR, AND COMMON CLOCK**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC78		SN74HC78		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5		3		4	MHz
		4.5 V	0	27		18		21	
		6 V	0	31		20		24	
t <sub>w</sub>	Pulse duration	CLR or PRE low	2 V	80	119		101		ns
			4.5 V	16	24		20		
			6 V	14	20		17		
	CLK high or low		2 V	80	119		101		ns
			4.5 V	16	24		20		
			6 V	14	20		17		
t <sub>su</sub>	Setup time before CLK ↓	CLR or PRE inactive or data	2 V	100	150		125		ns
			4.5 V	25	35		30		
			6 V	20	30		25		
t <sub>h</sub>	Hold time, data after CLK ↓		2 V	0	0		0		ns
			4.5 V	0	0		0		
			6 V	0	0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC78		SN74HC78		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	9		3		4		ns
			4.5 V	27	50		18		21		
			6 V	31	60		20		24		
t <sub>PHL</sub>	CLR	Q	2 V		78	155		250		194	ns
			4.5 V		16	31		47		39	
			6 V		13	26		40		32	
t <sub>PLH</sub>	CLR	Q̄	2 V		78	155		250		194	ns
			4.5 V		16	31		47		39	
			6 V		13	26		40		32	
t <sub>PHL</sub>	PRE	Q̄	2 V		78	155		250		194	ns
			4.5 V		16	31		47		39	
			6 V		13	26		40		32	
t <sub>PLH</sub>	PRE	Q	2 V		78	155		250		194	ns
			4.5 V		16	31		47		39	
			6 V		13	26		40		32	
t <sub>pd</sub>	CLK	Q	2 V		63	126		185		160	ns
			4.5 V		13	25		37		32	
			6 V		11	21		32		27	
t <sub>pd</sub>	CLK	Q̄	2 V		63	126		185		160	ns
			4.5 V		13	25		37		32	
			6 V		11	21		32		27	
t <sub>t</sub>			2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25 °C	30 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC85, SN74HC85 4-BIT MAGNITUDE COMPARATORS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs

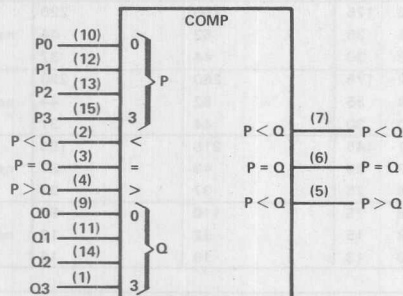
- Dependable Texas Instruments Quality and Reliability

### description

These four-bit magnitude comparators perform comparison of straight binary and straight BCD (8-4-2-1) codes. Three fully decoded decisions about two 4-bit words (P, Q) are made and are externally available at three outputs. These devices are fully expandable to any number of bits without external gates. Words of greater length may be compared by connecting comparators in cascade. The  $P > Q$ ,  $P < Q$ , and  $P = Q$  outputs of a stage handling less-significant bits are connected to the corresponding  $P > Q$ ,  $P < Q$ , and  $P = Q$  inputs of the next stage handling more-significant bits. The stage handling the least-significant bits must have a high-level voltage applied to the  $P = Q$  input. The cascading path of the 'HC85 is implemented with only a two-gate-level delay to reduce overall comparison times for long words.

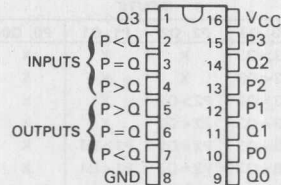
The SN54HC85 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC85 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

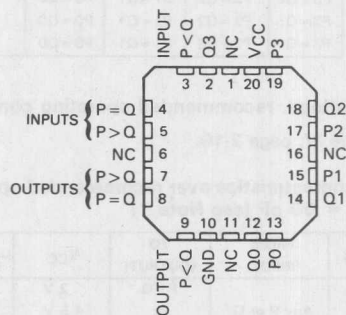


Pin numbers shown are for J and N packages.

SN54HC85... J PACKAGE  
SN74HC85... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC85... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

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# TYPES SN54HC85, SN74HC85 4-BIT MAGNITUDE COMPARATORS

FUNCTION TABLE

COMPARING INPUTS				CASCADING INPUTS			OUTPUTS		
P3, Q3	P2, Q2	P1, Q1	P0, Q0	P>Q	P<Q	P=Q	P>Q	P<Q	P=Q
P3>Q3	X	X	X	X	X	X	H	L	L
P3<Q3	X	X	X	X	X	X	L	H	L
P3=Q3	P2>Q2	X	X	X	X	X	H	L	L
P3=Q3	P2<Q2	X	X	X	X	X	L	H	L
P3=Q3	P2=Q2	P1>Q1	X	X	X	X	H	L	L
P3=Q3	P2=Q2	P1<Q1	X	X	X	X	L	H	L
P3=Q3	P2=Q2	P1=Q1	P0>Q0	X	X	X	H	L	L
P3=Q3	P2=Q2	P1=Q1	P0<Q0	X	X	X	L	H	L
P3=Q3	P2=Q2	P1=Q1	P0=Q0	H	L	L	H	L	L
P3=Q3	P2=Q2	P1=Q1	P0=Q0	L	H	L	L	H	L
P3=Q3	P2=Q2	P1=Q1	P0=Q0	X	X	H	L	L	H
P3=Q3	P2=Q2	P1=Q1	P0=Q0	H	H	L	L	L	L
P3=Q3	P2=Q2	P1=Q1	P0=Q0	L	L	L	H	H	L

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

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switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

ADVANCE INFORMATION

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC85		SN74HC85		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any P or Q	P>Q	2 V	80	230			345		290	ns
		or	4.5 V	26	46			69		58	
		P<Q	6 V	22	39			59		49	
$t_{pd}$	Any P or Q	P=Q	2 V	66	200			300		250	ns
			4.5 V	22	40			60		50	
			6 V	19	34			51		43	
$t_{pd}$	P<Q or P=Q	P>Q	2 V	63	175			260		220	ns
			4.5 V	21	35			52		44	
			6 V	18	30			44		37	
$t_{pd}$	P>Q or P=Q	P<Q	2 V	72	175			260		220	ns
			4.5 V	24	35			52		44	
			6 V	20	30			44		37	
$t_{pd}$	P=Q	P=Q	2 V	51	145			215		185	ns
			4.5 V	17	29			43		37	
			6 V	14	25			37		31	
$t_t$		Any	2 V	38	75			110		95	ns
			4.5 V	8	15			22		19	
			6 V	6	13			19		16	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	80 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# HIGH SPEED CMOS LOGIC

## TYPES SN54HC154, SN74HC154 4-LINE TO 16-LINE DECODERS/DEMULPLEXERS

D2684, DECEMBER 1982—REVISED MARCH 1984

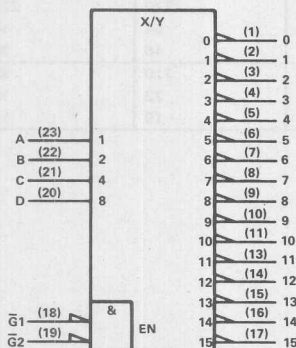
- Decodes 4 Binary-Coded Inputs into One of 16 Mutually Exclusive Outputs
- Performs the Demultiplexing Function by Distributing Data From One Input to Any One of 16 Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

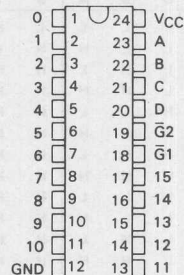
Each of these monolithic, 4-line to 16-line decoders decodes four binary-coded inputs into one of sixteen mutually exclusive outputs when both the strobe inputs,  $\bar{G}1$  and  $\bar{G}2$ , are low. The demultiplexing function is performed by using the 4 input lines to address the output line, passing data from one of the strobe inputs with the other strobe input low. When either strobe input is high, all outputs are high. These demultiplexers are ideally suited for implementing high-performance memory decoders.

The SN54HC154 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC154 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

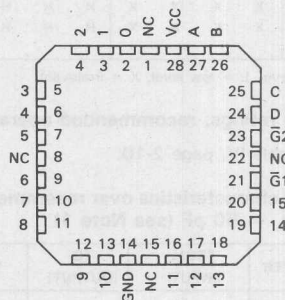
### logic symbols (alternatives)



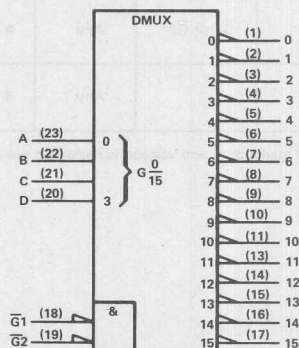
SN54HC154...JT PACKAGE  
SN74HC154...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC154...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection



Pin numbers shown are for JT and NT packages.

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## FUNCTION TABLE

H = high level, L = low level, X = irrelevant

maximum ratings, recommended operating conditions, and electrical characteristics

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC189, SN54HC219, SN74HC189, SN74HC219 64-BIT RANDOM-ACCESS MEMORIES WITH 3-STATE OUTPUTS**

D2684, DECEMBER 1982—REVISED MARCH 1984

- Organized as 16 Words of Four Bits Each
- Choice of Noninverted or Inverted Outputs
- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### **description**

Information to be stored in the memory is written into the selected address location when the chip-select ( $\bar{S}$ ) and the write-enable ( $R/\bar{W}$ ) inputs are low. While the write-enable input is low, the memory outputs are off (Hi-Z). When a number of outputs are bus-connected, this off state neither loads nor drives the data bus; however, it permits the bus line to be driven by the other active outputs or a passive pull-up.

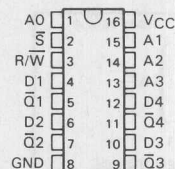
Information stored in the memory (see function table for input/output phase relationship) is available at the outputs when the write-enable input is high and the chip-select input is low. When the chip-select input is high, the outputs will be off.

The SN54HC189 and SN54HC219 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC189 and SN74HC219 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

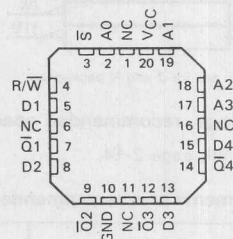
**FUNCTION TABLE**

FUNCTION	INPUTS		OUTPUTS	
	CHIP SELECT	WRITE ENABLE	'HC189	'HC219
Write	L	L	Z	Z
Read	L	H	Complement of data entered	Data entered
Inhibit	H	X	Z	Z

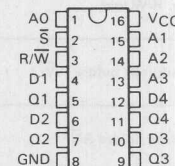
**SN54HC189... J PACKAGE  
SN74HC189... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



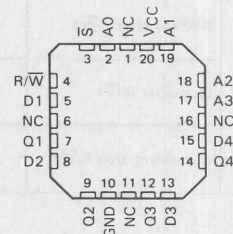
**SN54HC189... FH OR FK PACKAGE  
(TOP VIEW)**



**SN54HC219... J PACKAGE  
SN74HC219... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC219... FH OR FK PACKAGE  
(TOP VIEW)**



NC—No internal connection

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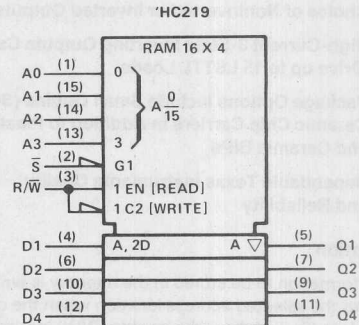
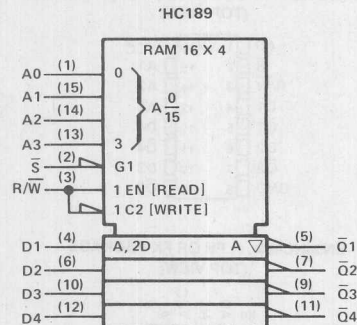
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# **TYPES SN54HC189, SN54HC219, SN74HC189, SN74HC219** **64-BIT RANDOM-ACCESS MEMORIES WITH 3-STATE OUTPUTS**

## logic symbols



Pin numbers shown are for J and N packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

## timing requirements over recommended operating free-air temperature range (unless otherwise noted)

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ADVANCE INFORMATION

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC189 SN54HC219	SN74HC189 SN74HC219	UNIT
			MIN	MAX	MIN	MAX	
t <sub>w</sub>	Pulse duration, R/ $\overline{W}$ low	2 V	275		400	350	ns
		4.5 V	55		80	70	
		6 V	47		68	60	
t <sub>su</sub>	Address before R/ $\overline{W}$ ↓	2 V	0		0	0	ns
		4.5 V	0		0	0	
		6 V	0		0	0	
	Data before R/ $\overline{W}$ ↑	2 V	275		400	350	
		4.5 V	55		80	70	
		6 V	47		68	60	
	Chip-select before R/ $\overline{W}$ ↑	2 V	275		400	350	
		4.5 V	55		80	70	
		6 V	47		68	60	
t <sub>h</sub>	Address after R/ $\overline{W}$ ↑	2 V	0		0	0	ns
		4.5 V	0		0	0	
		6 V	0		0	0	
	Data after R/ $\overline{W}$ ↑	2 V	0		0	0	
		4.5 V	0		0	0	
		6 V	0		0	0	
	Chip-select after R/ $\overline{W}$ ↑	2 V	0		0	0	
		4.5 V	0		0	0	
		6 V	0		0	0	

# **TYPES SN54HC189, SN54HC219, SN74HC189, SN74HC219** **64-BIT RANDOM-ACCESS MEMORIES WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted)  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (FROM)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC189 SN54HC219		SN74HC189 SN74HC219		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{a(ad)}$	A	Any	2 V		81						ns
			4.5 V		27						
			6 V		23						
$t_{a(S)}$	$\overline{S}$	Any	2 V		81						ns
			4.5 V		27						
			6 V		23						
$t_{en}$	R/ $\overline{W}$	Any	2 V		50						ns
			4.5 V		16						
			6 V		14						
$t_{dis}$	$\overline{S}$	Any	2 V		25						ns
			4.5 V		8						
			6 V		7						
	R/ $\overline{W}$	Any	2 V		35						
			4.5 V		11						
			6 V		10						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	55 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

## ADVANCE INFORMATION

# **HIGH-SPEED CMOS LOGIC**

# **TYPES SN54HCT189, SN54HCT219, SN74HCT189, SN74HCT219 64-BIT RANDOM-ACCESS MEMORIES WITH 3-STATE OUTPUTS**

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- Organized as 16 Words of Four Bits Each
- Choice of Noninverted or Inverted Outputs
- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## **description**

Information to be stored in the memory is written into the selected address location when the chip-select (S) and the write-enable (R/W) inputs are low. While the write-enable input is low, the memory outputs are off (Hi-Z). When a number of outputs are bus-connected, this off state neither loads nor drives the data bus; however, it permits the bus line to be driven by the other active outputs or a passive pull-up.

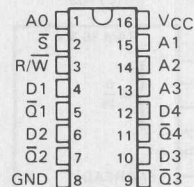
Information stored in the memory (see function table for input/output phase relationship) is available at the outputs when the write-enable input is high and the chip-select input is low. When the chip-select input is high, the outputs will be off.

The SN54HCT189 and SN54HCT219 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT189 and SN74HCT219 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

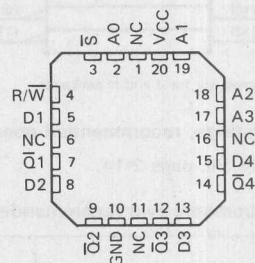
**FUNCTION TABLE**

FUNCTION	INPUTS		OUTPUTS	
	CHIP SELECT	WRITE ENABLE	'HCT189	'HCT219
Write	L	L	Z	Z
Read	L	H	Complement of data entered	Data entered
Inhibit	H	X	Z	Z

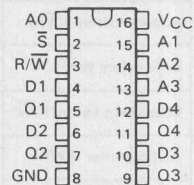
**SN54HCT189 ... J PACKAGE  
SN74HCT189 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



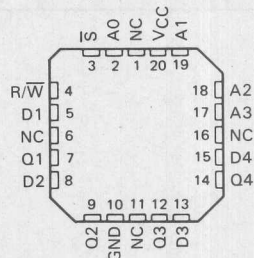
**SN54HCT189 ... FH OR FK PACKAGE  
(TOP VIEW)**



**SN54HCT219 ... J PACKAGE  
SN74HCT219 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HCT219 ... FH OR FK PACKAGE  
(TOP VIEW)**



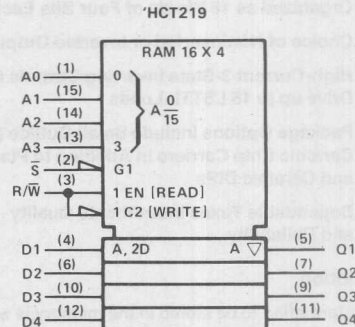
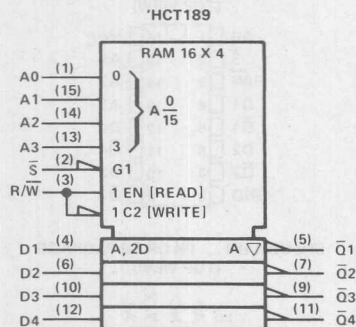
NC—No internal connection

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## logic symbols



Pin numbers shown are for J and N packages.

## maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

## timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HCT189 SN54HCT219		SN74HCT189 SN74HCT219		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub>	Pulse duration, R/ $\overline{W}$ low	4.5 V	55		80		70		ns
		5.5 V	50		75		63		
t <sub>su</sub>	Address before R/ $\overline{W}$ ↓	4.5 V	0		0		0		ns
		5.5 V	0		0		0		
	Data before R/ $\overline{W}$ ↑	4.5 V	55		80		70		ns
		5.5 V	50		75		63		
	Chip-select before R/ $\overline{W}$ ↑	4.5 V	55		80		70		ns
		5.5 V	50		75		63		
t <sub>h</sub>	Address after R/ $\overline{W}$ ↑	4.5 V	0		0		0		ns
		5.5 V	0		0		0		
	Data after R/ $\overline{W}$ ↑	4.5 V	0		0		0		ns
		5.5 V	0		0		0		
	Chip-select after R/ $\overline{W}$ ↑	4.5 V	0		0		0		ns
		5.5 V	0		0		0		



# TYPES SN54HCT189, SN54HCT219, SN74HCT189, SN74HCT219 64-BIT RANDOM-ACCESS MEMORIES WITH 3-STATE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT189 SN54HCT219		SN74HCT189 SN74HCT219		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{a(ad)}$	A	Any	4.5 V 5.5 V		27 23						ns
$t_{a(S)}$	$\bar{S}$	Any	4.5 V 5.5 V		27 23						ns
$t_{en}$	$R/\bar{W}$	Any	4.5 V 5.5 V		16 14						ns
$t_{dis}$	$\bar{S}$	Any	4.5 V		8						ns
			5.5 V		7						
	$R/\bar{W}$	Any	4.5 V 5.5 V		11 10						
$t_t$		Any	4.5 V		12						ns
			5.5 V		11						

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	55 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

## 4

# HIGH-SPEED CMOS LOGIC

# TYPES SN54HCT245, SN74HCT245 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs Are TTL-Voltage Compatible
- High-Current 3-State Outputs Drive Bus Lines Directly or Up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These octal bus transceivers are designed for asynchronous two-way communication between data buses. The control function implementation minimizes external timing requirements.

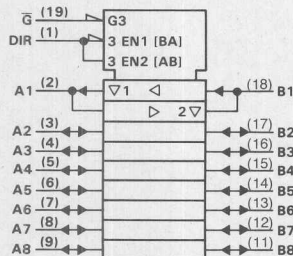
The devices allow data transmission from the A bus to the B bus or from the B bus to the A bus depending upon the logic level at the direction control (DIR) input. The enable input ( $\bar{G}$ ) can be used to disable the device so that the buses are effectively isolated.

The SN54HCT245 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT245 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

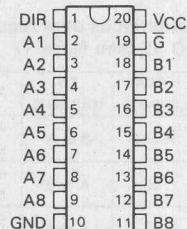
FUNCTION TABLE

CONTROL INPUTS		OPERATION
$\bar{G}$	DIR	
L	L	B data to A bus
L	H	A data to B bus
H	X	Isolation

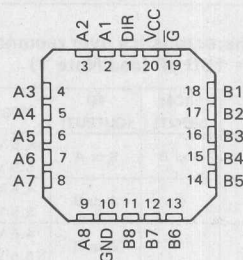
## logic symbol



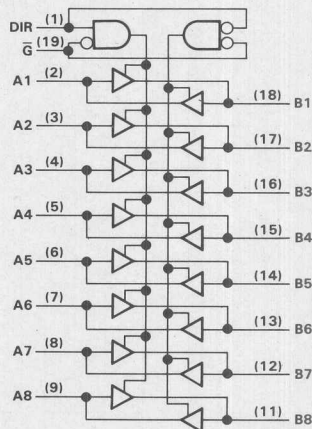
SN54HCT245...J PACKAGE  
SN74HCT245...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT245...FH OR FK PACKAGE  
(TOP VIEW)



## logic diagram



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ADVANCE INFORMATION

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**TYPES SN54HCT245, SN74HCT245**  
**OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT245		SN74HCT245		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		16	22		33		28	ns
			5.5 V		14	20		30		25	
t <sub>en</sub>	$\overline{G}$	A or B	4.5 V		25	46		69		58	ns
			5.5 V		22	41		62		52	
t <sub>dis</sub>	$\overline{G}$	A or B	4.5 V		26	40		60		50	ns
			5.5 V		23	36		54		45	
t <sub>t</sub>		A or B	4.5 V		9	12		18		15	ns
			5.5 V		8	11		16		14	
C <sub>pd</sub>	Power dissipation capacitance per transceiver					No load, T <sub>A</sub> = 25°C			40 pF typ		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT245		SN74HCT245		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		20	30		45		38	ns
			5.5 V		18	27		41		34	
t <sub>en</sub>	$\overline{G}$	A or B	4.5 V		36	59		89		74	ns
			5.5 V		30	63		80		67	
t <sub>t</sub>		A or B	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

D2804, MARCH 1984

- Full-Carry Look-Ahead Across the Four Bits
- Systems Achieve Partial Look-Ahead Performance with the Economy of Ripple Carry
- Supply Voltage and Ground on Corner Pins to Simplify P-C Board Layout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

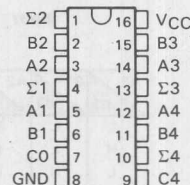
These improved full adders perform the addition of two 4-bit binary words. The sum ( $\Sigma$ ) outputs are provided for each bit and the resultant carry (C4) is obtained from the fourth bit.

These adders feature full internal look-ahead across all four bits generating the carry term. This capability provides the system designer with partial look-ahead performance at the economy and reduced package count of a ripple-carry implementation.

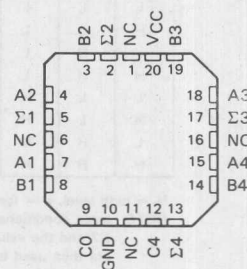
The adder logic, including the carry, is implemented in its true form. End around carry can be accomplished without the need for logic or level inversion.

The SN54HC283 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC283 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC283 . . . J PACKAGE  
SN74HC283 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC283 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

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ADVANCE INFORMATION

#### ADVANCE INFORMATION

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**TYPES SN54HC283, SN74HC283**  
**4-BIT BINARY FULL ADDERS WITH FAST CARRY**

FUNCTION TABLE

INPUT				OUTPUT							
				WHEN C0 = L				WHEN C0 = H			
				WHEN C2 = L				WHEN C2 = H			
A1	B1	A2	B2	$\Sigma 1$	$\Sigma 2$	C2	$\Sigma 1$	$\Sigma 2$	C2	$\Sigma 1$	$\Sigma 2$
A3	B3	A4	B4	$\Sigma 3$	$\Sigma 4$	C4	$\Sigma 3$	$\Sigma 4$	C4	$\Sigma 3$	$\Sigma 4$
L	L	L	L	L	L	L	H	L	L	L	L
H	L	L	L	H	L	L	L	H	L	L	L
L	H	L	L	H	L	L	L	H	L	L	L
H	H	L	L	L	H	L	H	H	L	L	L
L	L	H	L	L	H	L	H	H	L	L	L
H	L	H	L	H	H	L	L	L	L	H	H
L	H	H	L	H	H	L	L	L	L	H	H
H	H	H	L	L	L	H	H	L	L	H	H
L	L	L	H	L	H	L	H	H	L	L	L
H	L	L	H	H	H	L	L	L	L	H	H
L	H	L	H	H	H	L	L	L	L	H	H
H	H	L	H	L	L	H	H	L	L	H	H
L	L	H	H	L	L	H	H	L	L	H	H
H	L	H	H	H	L	H	L	H	L	H	H
L	H	H	H	H	L	H	L	H	L	H	H
H	H	H	H	L	H	H	H	H	L	H	H

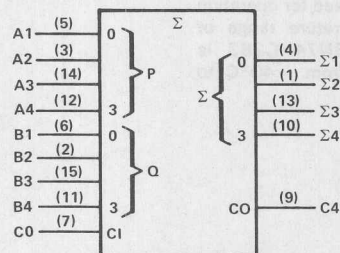
H = high level, L = low level

NOTE: Input conditions at A1, B1, A2, B2, and C0 are used to determine outputs  $\Sigma 1$  and  $\Sigma 2$  and the value of the internal carry C2. The values at C2, A3, B3, A4, and B4 are then used to determine outputs  $\Sigma 3$ ,  $\Sigma 4$ , and C4.

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ADVANCE INFORMATION

logic symbol

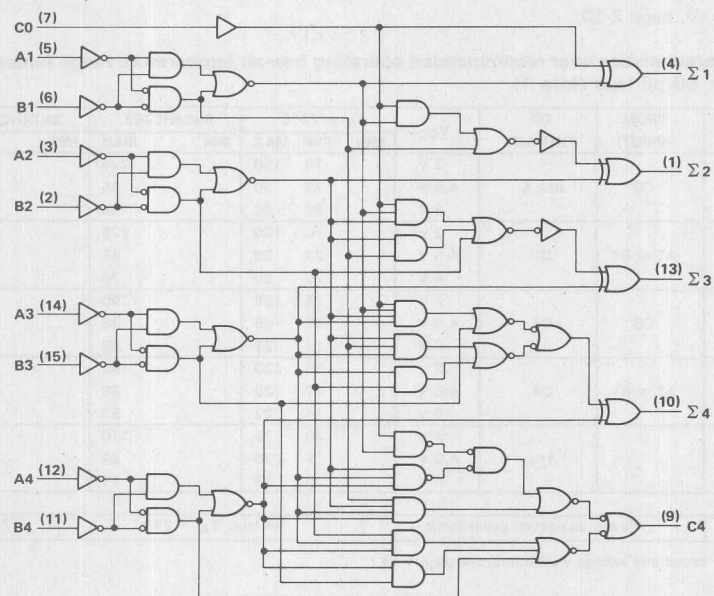


Pin numbers shown are for J and N packages.



**TYPES SN54HC283, SN74HC283**  
**4-BIT BINARY FULL ADDERS WITH FAST CARRY**

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

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ADVANCE INFORMATION

# **TYPES SN54HC283, SN74HC283** **4-BIT BINARY FULL ADDERS WITH FAST CARRY**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC283		SN74HC283		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	C0	Any $\Sigma$	2 V		70	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		20	26		38		32	
t <sub>pd</sub>	A1 or B1	$\Sigma$ 1	2 V		70	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		20	26		38		32	
t <sub>pd</sub>	C0	C4	2 V		55	125		190		155	ns
			4.5 V		17	25		38		31	
			6 V		14	21		32		26	
t <sub>pd</sub>	A1 or B1	C4	2 V		55	130		195		165	ns
			4.5 V		17	26		39		33	
			6 V		14	22		33		28	
t <sub>t</sub>		Any	2 V		28	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

4

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	75 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC299, SN74HC299 8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS WITH DIRECT CLEAR AND 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Multiplexed I/O Ports Provide Improved Bit Density
- Four Modes of Operation: Hold (Store), Shift Right, Shift Left, and Load Data
- High-Current 3-State Outputs Drive Bus Lines Directly or up to 15 LSTTL Loads
- Can Be Cascaded for N-Bit Word Lengths
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

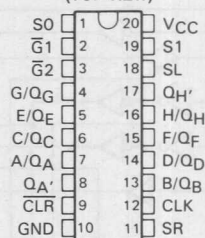
These eight-bit universal registers feature multiplexed I/O ports to achieve full eight-bit handling in a single 20-pin package. 'HC299 applications are as stacked or push-down registers, buffer storage, and accumulator registers.

Two function-select inputs and two output control inputs can be used to choose the modes of operation listed in the function table.

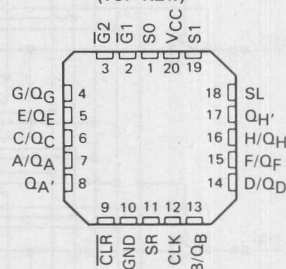
Synchronous parallel loading is accomplished by taking both function-select lines, S0 and S1, high. This places the three-state outputs in a high-impedance state. Which permits data that is applied on the I/O ports to be clocked into the register. Reading out of this register can be accomplished while the outputs enabled in any mode. A direct overriding input is provided to clear the register whether the outputs are enabled or off. Taking either of the output controls,  $\bar{G}1$  or  $\bar{G}2$ , high disables the outputs but this has no effect on shifting or storage of data.

The SN54HC299 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC299 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

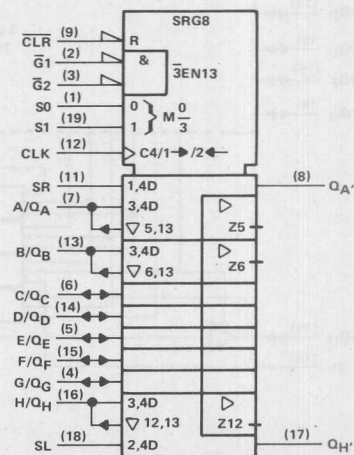
SN54HC299...J PACKAGE  
SN74HC299...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC299...FH OR FK PACKAGE  
(TOP VIEW)



### logic symbol



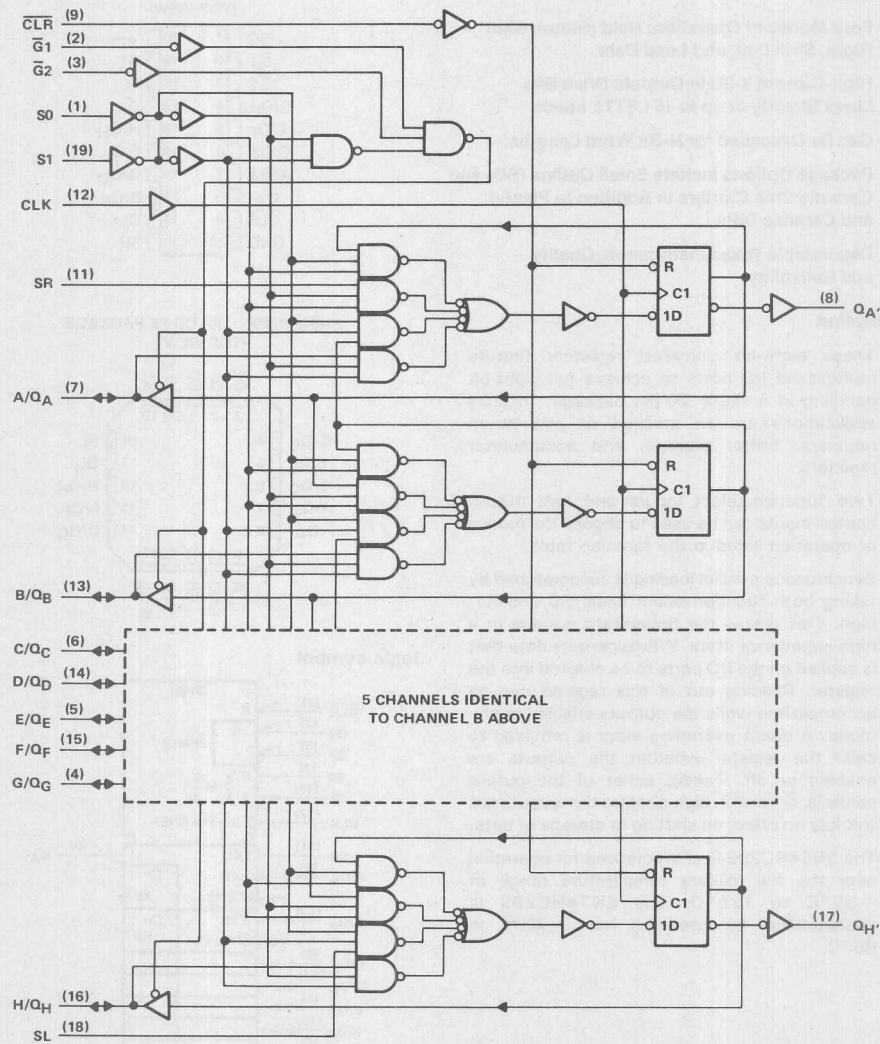
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subject to change without notice.

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**TYPES SN54HC299, SN74HC299**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH DIRECT CLEAR AND 3-STATE OUTPUTS**

logic diagram (positive logic)



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ADVANCE INFORMATION

**TYPES SN54HC299, SN74HC299**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH DIRECT CLEAR AND 3-STATE OUTPUTS**

FUNCTION TABLE

MODE	CLEAR	INPUTS					INPUTS/OUTPUTS										OUTPUTS	
		FUNCTION SELECT		OUTPUT CONTROL		CLOCK	SERIAL		A/Q <sub>A</sub>	B/Q <sub>B</sub>	C/Q <sub>C</sub>	D/Q <sub>D</sub>	E/Q <sub>E</sub>	F/Q <sub>F</sub>	G/Q <sub>G</sub>	H/Q <sub>H</sub>	Q <sub>A</sub> '	Q <sub>H</sub> '
		S1	S0	$\bar{G}1^\dagger$	$\bar{G}2^\dagger$		SL	SR										
Clear	L	X	L	L	L	X	X	X	L	L	L	L	L	L	L	L	L	L
	L	L	X	L	L	X	X	X	L	L	L	L	L	L	L	L	L	L
	L	H	H	X	X	X	X	X	X	X	X	X	X	X	X	X	L	L
Hold	H	L	X	L	L	L	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>	Q <sub>E0</sub>	Q <sub>F0</sub>	Q <sub>G0</sub>	Q <sub>H0</sub>	Q <sub>A0</sub>	Q <sub>H0</sub>
	H	X	L	L	L	L	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>	Q <sub>E0</sub>	Q <sub>F0</sub>	Q <sub>G0</sub>	Q <sub>H0</sub>	Q <sub>A0</sub>	Q <sub>H0</sub>
	H	H	H	L	L	L	X	X	X	X	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>H0</sub>
Shift Right	H	L	H	L	L	↑	X	H	H	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	H	Q <sub>Gn</sub>
	H	L	H	L	L	↑	X	L	L	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	L	Q <sub>Gn</sub>
Shift Left	H	H	L	L	L	↑	H	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	Q <sub>Hn</sub>	H	Q <sub>Bn</sub>	H
	H	H	L	L	L	↑	L	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	Q <sub>Hn</sub>	L	Q <sub>Bn</sub>	L
Load	H	H	H	X	X	↑	X	X	a	b	c	d	e	f	g	h	a	h

† When one or both output controls are high the eight input/output terminals are disabled to the high-impedance state; however, sequential operation or clearing of the register is not affected.

a . . . h = the level of the steady-state input at inputs A through H, respectively. These data are loaded into the flip-flops while the flip-flop outputs are isolated from the input/output terminals.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

**timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC299		SN74HC299		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	5	0	3.3	0	4	MHz
			4.5 V	0	25	0	17	0	20	
			6 V	0	29	0	19	0	24	
t <sub>w</sub>	Pulse duration	CLK high, CLK low, or $\bar{CLR}$ low	2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
t <sub>su</sub>	Setup time before CLK †	Select	2 V	150		225		190		ns
			4.5 V	30		45		38		
			6 V	25		38		32		
		Data or $\bar{CLR}$ inactive	2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
t <sub>h</sub>	Hold time after CLK †	Select or data	2 V	0		0		0		ns
			4.5 V	0		0		0		
			6 V	0		0		0		

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ADVANCE INFORMATION

**TYPES SN54HC299, SN74HC299**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH DIRECT CLEAR AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC299		SN74HC299		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	5			3.3		4		MHz
			4.5 V	25			17		20		
			6 V	29			19		24		
$t_{\text{pd}}$	CLK	$Q_A'$ or $Q_H'$	2 V		35						ns
			4.5 V		11						
			6 V		9						
		$Q_A$ thru $Q_H$	2 V		42						ns
$t_{\text{en}}$	$\overline{G}1$ or $\overline{G}2$	$Q_A$ thru $Q_H$	4.5 V		14						
			6 V		12						
			2 V		50						ns
	S0 or S1	$Q_A$ thru $Q_H$	4.5 V		15						
			6 V		12						
			2 V		50						ns
$t_{\text{dis}}$	$\overline{G}1$ or $\overline{G}2$	$Q_A$ thru $Q_H$	4.5 V		15						
			6 V		12						
			2 V		60						ns
	S0 or S1	$Q_A$ thru $Q_H$	4.5 V		20						
			6 V		17						
			2 V		60						ns
$t_{\text{PHL}}$	$\overline{\text{CLR}}$	$Q_A'$ or $Q_H'$	4.5 V		20						
			6 V		17						
			2 V		40						ns
		$Q_A$ thru $Q_H$	4.5 V		13						
			6 V		11						
			2 V		55						ns
$t_t$		Y	4.5 V		16						
			6 V		14						
			2 V		38						ns
			4.5 V		8						
			6 V		6						

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



**TYPES SN54HC299, SN74HC299**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH DIRECT CLEAR AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC299		SN74HC299		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CLK	$Q_A'$ or $Q_H'$	2 V		50						ns
			4.5 V		17						
			6 V		12						
		$Q_A$ thru $Q_H$	2 V		55						ns
			4.5 V		20						
			6 V		18						
$t_{en}$	$\overline{G}1$ or $\overline{G}2$	$Q_A$ thru $Q_H$	2 V		90						ns
			4.5 V		30						
			6 V		24						
	S0 or S1	$Q_A$ thru $Q_H$	2 V		90						ns
			4.5 V		30						
			6 V		24						
$t_{dis}$	$\overline{G}1$ or $\overline{G}2$	$Q_A$ thru $Q_H$	2 V		90						ns
			4.5 V		30						
			6 V		24						
	S0 or S1	$Q_A$ thru $Q_H$	2 V		90						ns
			4.5 V		30						
			6 V		24						
$t_{PHL}$	$\overline{CLR}$	$Q_A'$ or $Q_H'$	2 V		60						ns
			4.5 V		26						
			6 V		22						
		$Q_A$ thru $Q_H$	2 V		70						ns
			4.5 V		28						
			6 V		24						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION



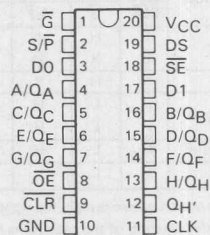
- Multiplexed Inputs/Outputs Provide Improved Bit Density
- High-Current 3-State Outputs Can Drive Up to 15 LSTTL Loads
- Sign Extend Function
- Direct Overriding Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

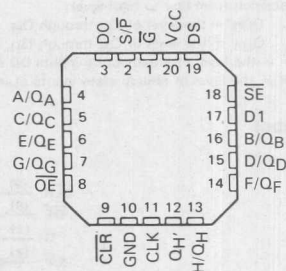
These eight-bit registers feature multiplexed input/output data ports to achieve full eight-bit handling in a single 20-pin package. Serial data may be entered into the shift-register through either the D0 or the D1 input as selected by the data select input DS. A serial output  $Q_H'$  is also provided to facilitate expansion. Synchronous parallel loading is accomplished by taking both the register enable  $\bar{G}$  and the  $S/\bar{P}$  input low. This places the three-state input/output ports in the data input mode. Data are entered on the low-to-high transition of the clock. The sign extend function repeats the sign in the  $Q_A$  flip-flop during shifting if the sign extend input  $\bar{SE}$  is low. A direct overriding clear input clears the internal registers when taken low whether the outputs are enabled or off. The output enable does not interfere with synchronous operation of the register.

The SN54HC322 is characterized for operation over the full military range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC322 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**SN54HC322... J PACKAGE  
SN74HC322... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC322... FH OR FK PACKAGE  
(TOP VIEW)**



NC--No internal connection

#### ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

# **TYPES SN54HC322, SN74HC322** **8-BIT SHIFT REGISTERS WITH SIGN EXTEND AND 3-STATE OUTPUTS**

FUNCTION TABLE

OPERATION	INPUTS							INPUTS/OUTPUTS				OUTPUT Q <sub>H</sub> '
	CL <sub>R</sub>	$\overline{G}$	S/ $\overline{P}$	$\overline{S}E$	DS	$\overline{OE}$	CLK	A/Q <sub>A</sub>	B/Q <sub>B</sub>	C/Q <sub>C</sub> . . . H/Q <sub>H</sub>		
Clear	L	H	X	X	X	L	X	L	L	L	L	L
	L	X	H	X	X	L	X	L	L	L	L	L
Hold	H	H	X	X	X	L	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>H0</sub>	Q <sub>H0</sub>
Shift Right	H	L	H	H	L	L	↑	D0	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Gn</sub>	Q <sub>Gn</sub>
	H	L	H	H	H	L	↑	D1	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Gn</sub>	Q <sub>Gn</sub>
Sign Extend	H	L	H	L	X	L	↑	Q <sub>An</sub>	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Gn</sub>	Q <sub>Gn</sub>
Load	H	L	L	X	X	X	↑	a	b	c	h	h

When the output enable is high, the eight input/output terminals are disabled to the high-impedance state; however, sequential operation or clearing of the register is not affected. If both the register enable input and the S/ $\overline{P}$  are low while the clear input is low, the register is cleared while the eight input/output terminals are disabled to the high-impedance state.

H = high level (steady state)

L = low level (steady state)

X = irrelevant (any input, including transitions)

↑ = transition from low to high level

Q<sub>A0</sub> . . . Q<sub>H0</sub> = the level of Q<sub>A</sub> through Q<sub>H</sub>, respectively, before the indicated steady-state conditions were established

Q<sub>An</sub> . . . Q<sub>Hn</sub> = the level of Q<sub>A</sub> through Q<sub>H</sub>, respectively, before the most recent ↑ transition of the clock.

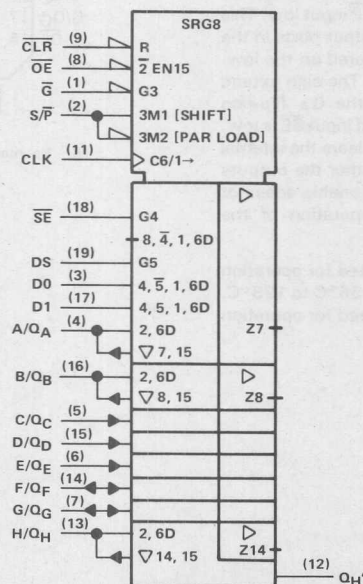
D0, D1 = the level of steady-state inputs D0 and D1 respectively

a . . . h = the level of steady-state inputs at inputs A through H respectively

logic symbol

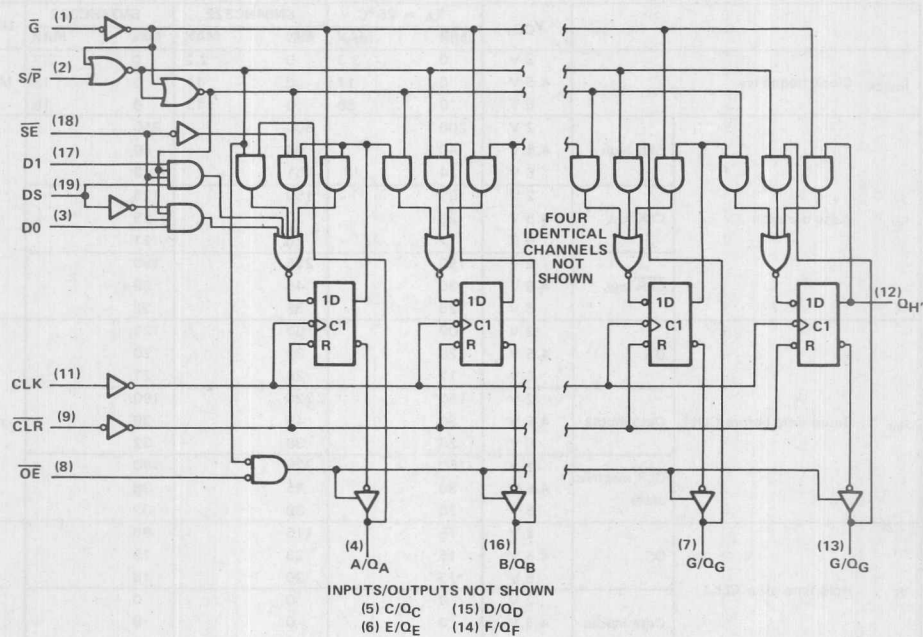
4

ADVANCE INFORMATION



**TYPES SN54HC322, SN74HC322**  
**8-BIT SHIFT REGISTERS WITH SIGN EXTEND AND 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

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ADVANCE INFORMATION

**TYPES SN54HC322, SN74HC322**  
**8-BIT SHIFT REGISTERS WITH SIGN EXTEND AND 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC322		SN74HC322		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	3.3	0	2.2	0	2.7	MHz
		4.5 V	0	17	0	11	0	13	
		6 V	0	20	0	13	0	16	
t <sub>w</sub>	CLK high	2 V	200		300		250		ns
		4.5 V	40		60		50		
		6 V	34		51		43		
	CLK low	2 V	100		150		125		
		4.5 V	20		30		25		
		6 V	17		26		21		
	CLR low	2 V	150		225		190		
		4.5 V	30		45		38		
		6 V	26		38		32		
t <sub>su</sub>	DS	2 V	100		150		125		ns
		4.5 V	20		30		20		
		6 V	17		26		21		
	Data inputs	2 V	150		225		190		
		4.5 V	30		45		38		
		6 V	26		38		32		
	CLR inactive state	2 V	150		225		190		
		4.5 V	30		45		38		
		6 V	26		38		32		
t <sub>h</sub>	DS	2 V	75		115		95		ns
		4.5 V	15		23		19		
		6 V	13		20		16		
	Data inputs	2 V	0		0		0		
		4.5 V	0		0		0		
		6 V	0		0		0		

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ADVANCE INFORMATION



# **TYPES SN54HC322, SN74HC322** **8-BIT SHIFT REGISTERS WITH SIGN EXTEND AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC322		SN74HC322		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V								MHz
			4.5 V	3.3	6		2.2		2.7		
			6 V	17	35		11		13		
t <sub>pd</sub>	Clock	Q <sub>H</sub> '	2 V			95					ns
			4.5 V			31					
			6 V			26					
t <sub>PHL</sub>	Clear	Q <sub>H</sub> '	2 V			95					ns
			4.5 V			32					
			6 V			27					
t <sub>pd</sub>	Clock	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			80					ns
			4.5 V			26					
			6 V			22					
t <sub>PHL</sub>	Clear	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			80					ns
			4.5 V			26					
			6 V			22					
t <sub>en</sub>	Output enable	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			55					ns
			4.5 V			18					
			6 V			15					
t <sub>dis</sub>	Output enable	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			55					ns
			4.5 V			18					
			6 V			15					
t <sub>t</sub>			2 V			38					ns
			4.5 V			8					
			6 V			6					

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

Timing diagram for the 6-bit shift register with 2-bit extend and 2-bit output. The diagram shows the relationship between the clock signal (CLK), the extend input (EXT), the data input (D), the data output (Q), and the extend output (EXTOUT). The clock signal is a square wave. The extend input is a square wave. The data input is a square wave. The data output is a square wave. The extend output is a square wave.

TEST	EXT	D	Q	EXTOUT
1	0	0	0	0
2	0	1	1	0
3	0	0	0	0
4	0	1	1	0
5	0	0	0	0
6	0	1	1	0
7	0	0	0	0
8	0	1	1	0
9	0	0	0	0
10	0	1	1	0
11	0	0	0	0
12	0	1	1	0
13	0	0	0	0
14	0	1	1	0
15	0	0	0	0
16	0	1	1	0
17	0	0	0	0
18	0	1	1	0
19	0	0	0	0
20	0	1	1	0
21	0	0	0	0
22	0	1	1	0
23	0	0	0	0
24	0	1	1	0
25	0	0	0	0
26	0	1	1	0
27	0	0	0	0
28	0	1	1	0
29	0	0	0	0
30	0	1	1	0
31	0	0	0	0
32	0	1	1	0
33	0	0	0	0
34	0	1	1	0
35	0	0	0	0
36	0	1	1	0
37	0	0	0	0
38	0	1	1	0
39	0	0	0	0
40	0	1	1	0
41	0	0	0	0
42	0	1	1	0
43	0	0	0	0
44	0	1	1	0
45	0	0	0	0
46	0	1	1	0
47	0	0	0	0
48	0	1	1	0
49	0	0	0	0
50	0	1	1	0
51	0	0	0	0
52	0	1	1	0
53	0	0	0	0
54	0	1	1	0
55	0	0	0	0
56	0	1	1	0
57	0	0	0	0
58	0	1	1	0
59	0	0	0	0
60	0	1	1	0
61	0	0	0	0
62	0	1	1	0
63	0	0	0	0
64	0	1	1	0
65	0	0	0	0
66	0	1	1	0
67	0	0	0	0
68	0	1	1	0
69	0	0	0	0
70	0	1	1	0
71	0	0	0	0
72	0	1	1	0
73	0	0	0	0
74	0	1	1	0
75	0	0	0	0
76	0	1	1	0
77	0	0	0	0
78	0	1	1	0
79	0	0	0	0
80	0	1	1	0
81	0	0	0	0
82	0	1	1	0
83	0	0	0	0
84	0	1	1	0
85	0	0	0	0
86	0	1	1	0
87	0	0	0	0
88	0	1	1	0
89	0	0	0	0
90	0	1	1	0
91	0	0	0	0
92	0	1	1	0
93	0	0	0	0
94	0	1	1	0
95	0	0	0	0
96	0	1	1	0
97	0	0	0	0
98	0	1	1	0
99	0	0	0	0
100	0	1	1	0

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### ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC323, SN74HC323 8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS WITH SYNCHRONOUS CLEAR AND 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Multiplexed I/O Ports Provide Improved Bit Density
- Four Modes of Operation: Hold (Store), Shift Right, Shift Left, and Load Data
- High-Current 3-State Outputs Drive Bus Lines Directly or up to 15 LSTTL Loads
- Can Be Cascaded for N-Bit Word Lengths
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

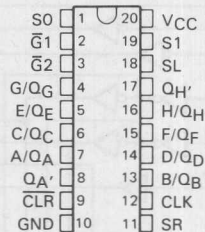
These eight-bit universal registers feature multiplexed I/O ports to achieve full eight-bit handling in a single 20-pin package. 'HC323 applications are as stacked or push-down registers, buffer storage, and accumulator registers.

Two function-select inputs and two output control inputs can be used to choose the modes of operation listed in the function table.

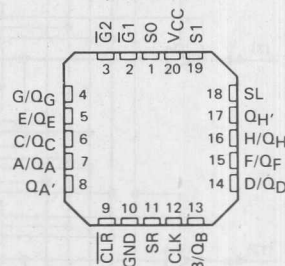
Synchronous parallel loading is accomplished by taking both function-select lines, S0 and S1, high. This places the three-state outputs in a high-impedance state, which permits data that is applied on the I/O ports to be clocked into the register. Reading out of this register can be accomplished while the outputs are enabled in any mode. The clear function is synchronous, and a low level at the clear input clears the register on the next low-to-high transition of the clock.

The SN54HC323 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC323 is characterized for operation from -40°C to 85°C.

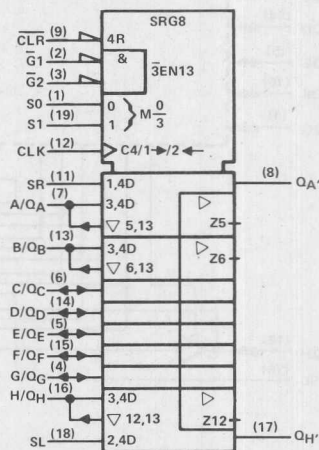
SN54HC323...J PACKAGE  
SN74HC323...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC323...FH OR FK PACKAGE  
(TOP VIEW)



### logic symbol



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ADVANCE INFORMATION

### ADVANCE INFORMATION

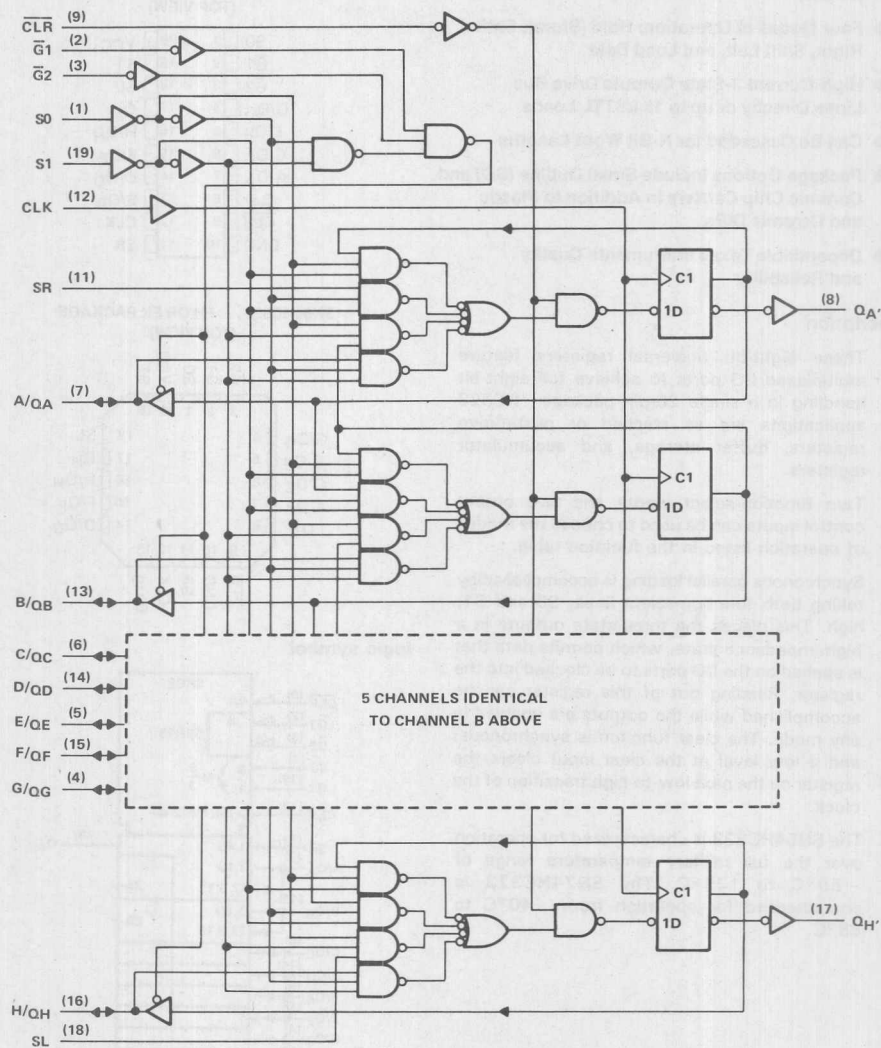
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**TYPES SN54HC323, SN74HC323**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH SYNCHRONOUS CLEAR AND 3-STATE OUTPUTS**

logic diagram (positive logic)



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ADVANCE INFORMATION

**TYPES SN54HC323, SN74HC323**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH SYNCHRONOUS CLEAR AND 3-STATE OUTPUTS**

FUNCTION TABLE

MODE	INPUTS						INPUTS/OUTPUTS										OUTPUTS	
	CLEAR	FUNCTION SELECT		OUTPUT CONTROL		CLOCK	SERIAL		A/Q <sub>A</sub>	B/Q <sub>B</sub>	C/Q <sub>C</sub>	D/Q <sub>D</sub>	E/Q <sub>E</sub>	F/Q <sub>F</sub>	G/Q <sub>G</sub>	H/Q <sub>H</sub>	Q <sub>A</sub> '	Q <sub>H</sub> '
		S1	S0	$\overline{G1}^\dagger$	$\overline{G2}^\dagger$		SL	SR										
Clear	L	X	L	L	L	↑	X	X	L	L	L	L	L	L	L	L	L	L
	L	L	X	L	L	↑	X	X	L	L	L	L	L	L	L	L	L	L
	L	H	H	X	X	↑	X	X	X	X	X	X	X	X	X	X	L	L
Hold	H	L	X	L	L	L	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>	Q <sub>E0</sub>	Q <sub>F0</sub>	Q <sub>G0</sub>	Q <sub>H0</sub>	Q <sub>A0</sub>	Q <sub>H0</sub>
	H	X	L	L	L	L	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>	Q <sub>E0</sub>	Q <sub>F0</sub>	Q <sub>G0</sub>	Q <sub>H0</sub>	Q <sub>A0</sub>	Q <sub>H0</sub>
	H	H	H	L	L	L	X	X	X	X	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>H0</sub>
Shift Right	H	L	H	L	L	↑	X	H	H	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	H	Q <sub>Gn</sub>
	H	L	H	L	L	↑	X	L	L	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	L	Q <sub>Gn</sub>
Shift Left	H	H	L	L	L	↑	H	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	Q <sub>Hn</sub>	H	Q <sub>Bn</sub>	H
	H	H	L	L	L	↑	L	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	Q <sub>En</sub>	Q <sub>Fn</sub>	Q <sub>Gn</sub>	Q <sub>Hn</sub>	L	Q <sub>Bn</sub>	L
Load	H	H	H	X	X	↑	X	X	a	b	c	d	e	f	g	h	a	h

† When one or both output controls are high the eight input/output terminals are disabled to the high-impedance state; however, sequential operation or clearing of the register is not affected.

a . . . h = the level of the steady-state input at inputs A through H, respectively. These data are loaded into the flip-flops while the flip-flop outputs are isolated from the input/output terminals.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

**timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC323		SN74HC323		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	5	0	3.3	0	4	MHz
			4.5 V	0	25	0	17	0	20	
			6 V	0	29	0	19	0	24	
t <sub>w</sub>	Pulse duration	CLK high or low	2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
t <sub>su</sub>	Setup time before CLK ↑	S0 or S1	2 V	150		225		190		ns
			4.5 V	30		45		38		
			6 V	26		38		32		
	$\overline{\text{CLR}}$ low or data		2 V	100		150		125		
			4.5 V	20		30		25		
			6 V	17		26		21		
t <sub>h</sub>	Hold time after CLK ↑	S0 or S1, data, or $\overline{\text{CLR}}$ low	2 V	0		0		0		ns
			4.5 V	0		0		0		
			6 V	0		0		0		

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ADVANCE INFORMATION

**TYPES SN54HC323, SN74HC323**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH SYNCHRONOUS CLEAR AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC323		SN74HC323		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$			2 V	5			3.3		4		MHz
			4.5 V	25			17		20		
			6 V	29			19		24		
$t_{pd}$	CLK	$Q_A'$ or $Q_H'$	2 V		36						ns
			4.5 V		12						
			6 V		10						
		$Q_A$ thru $Q_H$	2 V		50						
			4.5 V		14						
			6 V		12						
$t_{en}$	$\bar{G}1, \bar{G}2$	$Q_A$ thru $Q_H$	2 V		50						ns
			4.5 V		15						
			6 V		12						
	S0 or S1	$Q_A$ thru $Q_H$	2 V		50						
			4.5 V		15						
			6 V		12						
$t_{dis}$	$\bar{G}1, \bar{G}2$	$Q_A$ thru $Q_H$	2 V		60						ns
			4.5 V		20						
			6 V		17						
	S0 or S1	$Q_A$ thru $Q_H$	2 V		60						
			4.5 V		20						
			6 V		17						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



**TYPES SN54HC323, SN74HC323**  
**8-BIT UNIVERSAL SHIFT/STORAGE REGISTERS**  
**WITH SYNCHRONOUS CLEAR AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC323		SN74HC323		UNIT	
				MIN	TYP	MAX	MIN	MAX	MIN	MAX		
t <sub>pd</sub>	CLK	Q <sub>A</sub> ' or Q <sub>H</sub> '	2 V		50						ns	
			4.5 V		17							
			6 V		15							
		Q <sub>A</sub> thru Q <sub>H</sub>	2 V		50							
			4.5 V		17							
			6 V		15							
t <sub>en</sub>	G̅1, G̅2	Q <sub>A</sub> thru Q <sub>H</sub>	2 V		90						ns	
			4.5 V		30							
			6 V		24							
	S0 or S1		2 V		90							
			4.5 V		30							
			6 V		24							
t <sub>dis</sub>	G̅1, G̅2	Q <sub>A</sub> thru Q <sub>H</sub>	2 V		90						ns	
			4.5 V		30							
			6 V		24							
	S0 or S1		2 V		90							
			4.5 V		30							
			6 V		24							
t <sub>t</sub>		Any	2 V		45						ns	
			4.5 V		17							
			6 V		13							

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

## ADVANCE INFORMATION

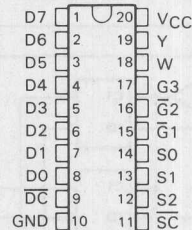
# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC354, SN74HC354 8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/ TRANSPARENT REGISTERS WITH 3-STATE OUTPUTS**

D2684, DECEMBER 1982—REVISED MARCH 1984

- Transparent Latches on Data Select Inputs
- Transparent Data Registers
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Complementary Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC354... J PACKAGE  
SN74HC354... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

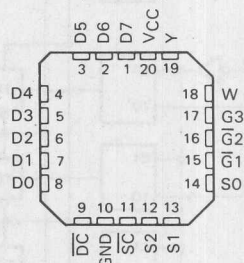


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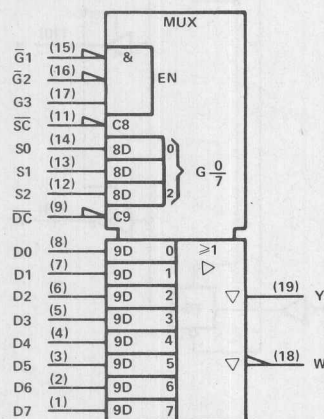
These monolithic data selectors/multiplexers contain full on-chip binary decoding to select one of eight data sources. The data-select is stored in transparent latches that are enabled by a low level on pin 11,  $\overline{SC}$ . A similar enable for data is obtained by a low level on pin 9,  $\overline{DC}$ .

The SN54HC354 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC354 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC354... FH OR FK PACKAGE  
(TOP VIEW)



### **logic symbol**



**ADVANCE INFORMATION**  
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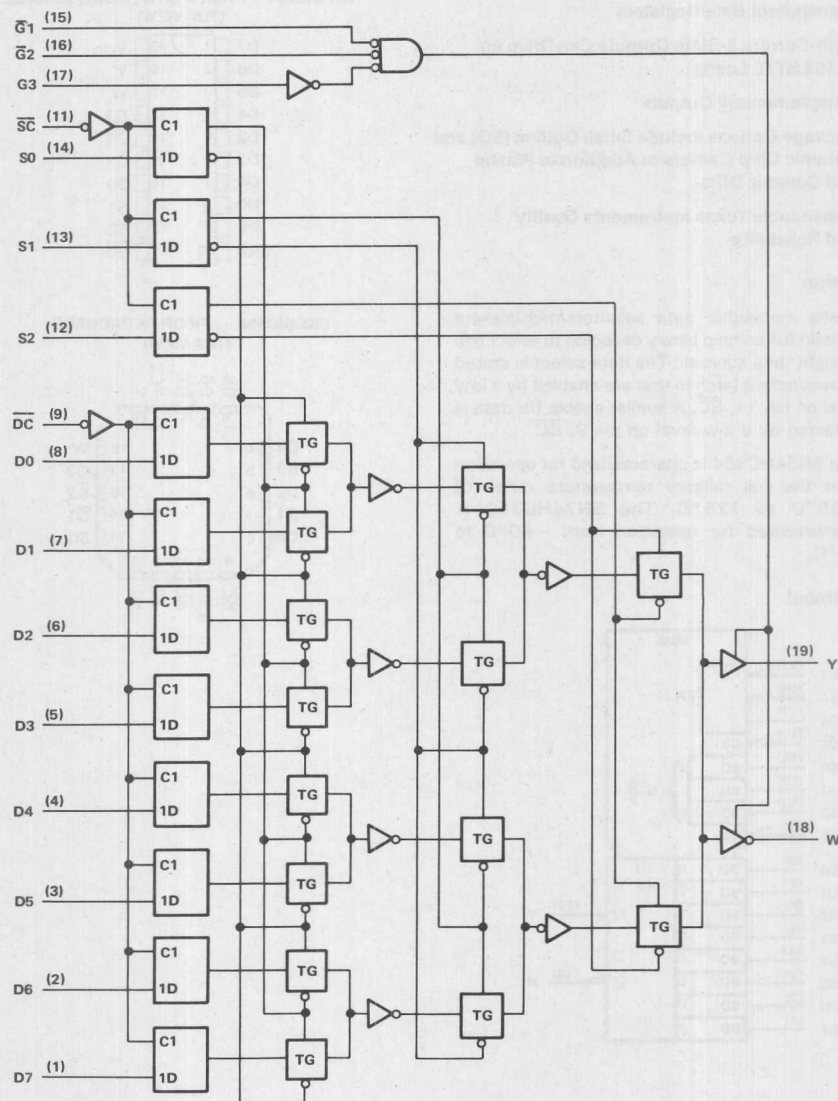
4-43

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ADVANCE INFORMATION

**TYPES SN54HC354, SN74HC354**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**TRANSPARENT REGISTERS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



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ADVANCE INFORMATION

**TYPES SN54HC354, SN74HC354**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**TRANSPARENT REGISTERS WITH 3-STATE OUTPUTS**

FUNCTION TABLE

INPUTS							OUTPUTS	
SELECT†			DATA CONTROL	OUTPUT ENABLES				
S2	S1	S0	DC	G1	G2	G3	W	Y
X	X	X	X	H	X	X	Z	Z
X	X	X	X	X	H	X	Z	Z
X	X	X	X	X	X	L	Z	Z
L	L	L	L	L	L	H	D0	D0
L	L	L	H	L	L	H	D0 <sub>n</sub>	D0 <sub>n</sub>
L	L	H	L	L	L	H	D1	D1
L	L	H	H	L	L	H	D1 <sub>n</sub>	D1 <sub>n</sub>
L	H	L	L	L	L	H	D2	D2
L	H	L	H	L	L	H	D2 <sub>n</sub>	D2 <sub>n</sub>
L	H	H	L	L	L	H	D3	D3
L	H	H	H	L	L	H	D3 <sub>n</sub>	D3 <sub>n</sub>
H	L	L	L	L	L	H	D4	D4
H	L	L	H	L	L	H	D4 <sub>n</sub>	D4 <sub>n</sub>
H	L	H	L	L	L	H	D5	D5
H	L	H	H	L	L	H	D5 <sub>n</sub>	D5 <sub>n</sub>
H	H	L	L	L	L	H	D6	D6
H	H	L	H	L	L	H	D6 <sub>n</sub>	D6 <sub>n</sub>
H	H	H	L	L	L	H	D7	D7
H	H	H	H	L	L	H	D7 <sub>n</sub>	D7 <sub>n</sub>

H = high level (steady state)

L = low level (steady state)

X = irrelevant (any input, including transitions)

Z = high-impedance state (off state)

† = transition from low to high level

D0 . . . D7 = the level of steady-state inputs at inputs D0 through D7, respectively

D0<sub>n</sub> . . . D7<sub>n</sub> = the level of steady state inputs at inputs D0 through D7, respectively, before the most recent low-to-high transition of data control

† This column shows the input address setup with  $\overline{SC}$  low.

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		VCC	T <sub>A</sub> = 25 °C		SN54HC354		SN74HC354		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>su</sub>	Setup time, data before $\overline{DC}$ †	2 V	75		115		95		ns
		4.5 V	15		23		19		
		6 V	13		20		16		
t <sub>h</sub>	Hold time, data after $\overline{DC}$ †	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		

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ADVANCE INFORMATION

**TYPES SN54HC354, SN74HC354**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**TRANSPARENT REGISTERS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC354		SN74HC354		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D0–D07	Y	2 V		90						ns
			4.5 V		29						
			6 V		25						
		W	2 V		85						ns
			4.5 V		28						
			6 V		24						
$t_{pd}$	$\overline{DC}$	Y	2 V		85						ns
			4.5 V		28						
			6 V		24						
		W	2 V		85						ns
			4.5 V		28						
			6 V		24						
$t_{pd}$	S0, S1, S2	Y	2 V		100						ns
			4.5 V		32						
			6 V		27						
		W	2 V		90						ns
			4.5 V		30						
			6 V		26						
$t_{pd}$	$\overline{SC}$	Y	2 V		85						ns
			4.5 V		28						
			6 V		24						
		W	2 V		80						ns
			4.5 V		26						
			6 V		22						
$t_{en}$	$\overline{G}1, \overline{G}2$	Y	2 V		75						ns
			4.5 V		24						
			6 V		20						
		W	2 V		75						ns
			4.5 V		24						
			6 V		20						
$t_{dis}$	$\overline{G}1, \overline{G}2$	Y	2 V		45						ns
			4.5 V		15						
			6 V		13						
		W	2 V		45						ns
			4.5 V		15						
			6 V		13						
$t_{en}$	G3	Y	2 V		75						ns
			4.5 V		24						
			6 V		20						
		W	2 V		75						ns
			4.5 V		24						
			6 V		20						
$t_{dis}$	G3	Y	2 V		50						ns
			4.5 V		17						
			6 V		15						
		W	2 V		50						ns
			4.5 V		17						
			6 V		15						

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	40 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC356, SN74HC356 8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/ EDGE-TRIGGERED REGISTERS WITH 3-STATE OUTPUTS**

D2684, DECEMBER 1982—REVISED MARCH 1984

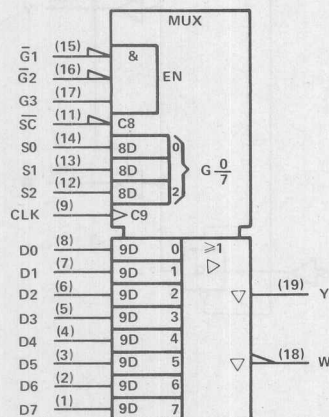
- Transparent Latches on Data Select Inputs
- Edge-Triggered Data Registers
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Complementary Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### **description**

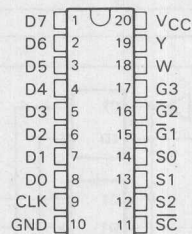
These monolithic data selectors/multiplexers contain full on-chip binary decoding to select one of eight data sources. The data-select address is stored in transparent latches that are enabled by a low level on pin 11,  $\overline{SC}$ . The edge-triggered data registers are clocked by a low-to-high transition on pin 9, CLK. Both true and complementary outputs are available.

The SN54HC356 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC356 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

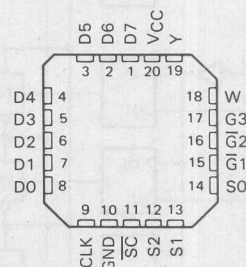
### **logic symbol**



SN54HC356 ... J PACKAGE  
SN74HC356 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC356 ... FH OR FK PACKAGE  
(TOP VIEW)



4

ADVANCE INFORMATION

ADVANCE INFORMATION  
This document contains information  
on a new product. Specifications are  
subject to change without notice.

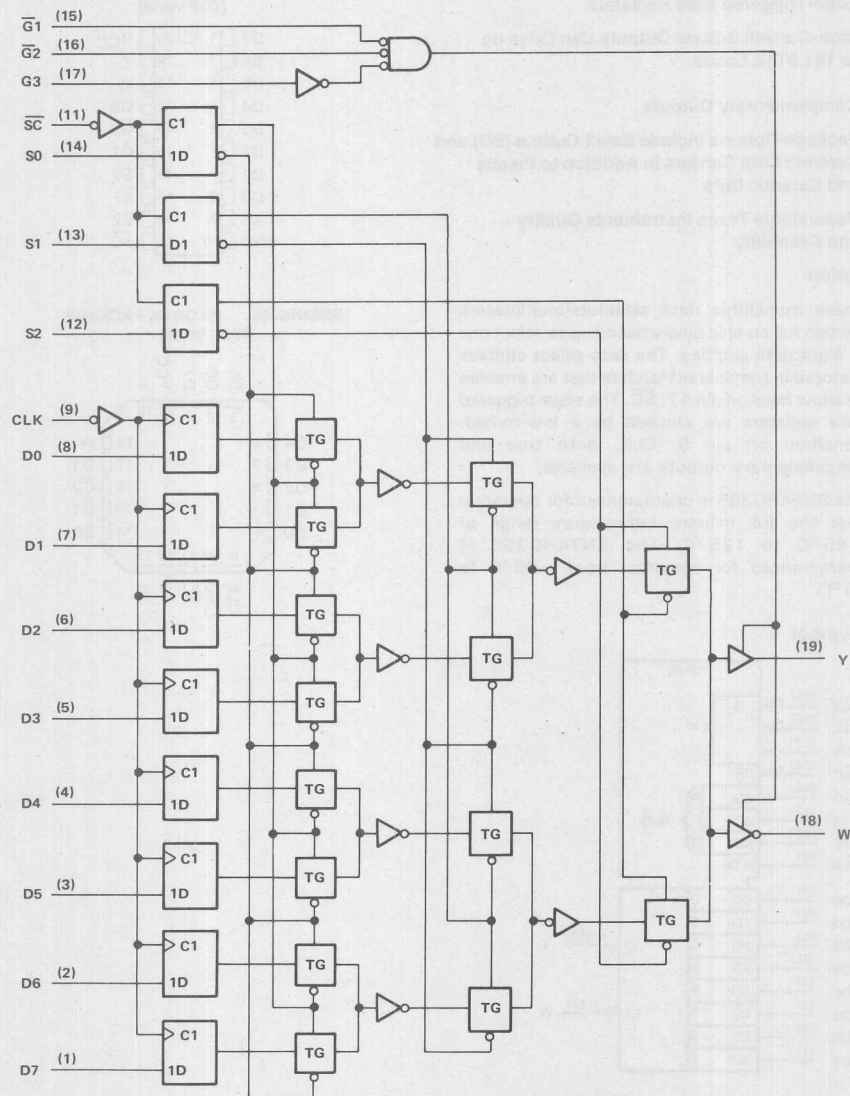
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**TYPES SN54HC356, SN74HC356**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**EDGE-TRIGGERED REGISTERS WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



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ADVANCE INFORMATION

**TYPES SN54HC356, SN74HC356**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**EDGE-TRIGGERED REGISTERS WITH 3-STATE OUTPUTS**

FUNCTION TABLE

INPUTS						OUTPUTS		
SELECT <sup>†</sup>			CLOCK	OUTPUT ENABLES				
				S2	S1	S0	G1	G2
X	X	X	X	H	X	X	Z	Z
X	X	X	X	X	H	X	Z	Z
X	X	X	X	X	X	L	Z	Z
L	L	L	↑	L	L	H	$\overline{D}0$	D0
L	L	L	H or L	L	L	H	$\overline{D}0_n$	D0 <sub>n</sub>
L	L	H	↑	L	L	H	$\overline{D}1$	D1
L	L	H	H or L	L	L	H	$\overline{D}1_n$	D1 <sub>n</sub>
L	H	L	↑	L	L	H	$\overline{D}2$	D2
L	H	L	H or L	L	L	H	$\overline{D}2_n$	D2 <sub>n</sub>
L	H	H	↑	L	L	H	$\overline{D}3$	D3
L	H	H	H or L	L	L	H	$\overline{D}3_n$	D3 <sub>n</sub>
H	L	L	↑	L	L	H	$\overline{D}4$	D4
H	L	L	H or L	L	L	H	$\overline{D}4_n$	D4 <sub>n</sub>
H	L	H	↑	L	L	H	$\overline{D}5$	D5
H	L	H	H or L	L	L	H	$\overline{D}5_n$	D5 <sub>n</sub>
H	H	L	↑	L	L	H	$\overline{D}6$	D6
H	H	L	H or L	L	L	H	$\overline{D}6_n$	D6 <sub>n</sub>
H	H	H	↑	L	L	H	$\overline{D}7$	D7
H	H	H	H or L	L	L	H	$\overline{D}7_n$	D7 <sub>n</sub>

<sup>†</sup>This column shows the input address setup with  $\overline{SC}$  low.

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC356		SN74HC356		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>su</sub>	Setup time, data before CLK <sup>†</sup>	2 V	75		115		95		ns
		4.5 V	15		23		19		
		6 V	13		20		16		
t <sub>h</sub>	Hold time, data after CLK <sup>†</sup>	2 V	5		5		5		ns
		4.5 V	5		5		5		
		6 V	5		5		5		

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ADVANCE INFORMATION

**TYPES SN54HC356, SN74HC356**  
**8-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS/**  
**EDGE-TRIGGERED REGISTERS WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC356		SN74HC356		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CLK	Y	2 V		95						ns
			4.5 V		31						
			6 V		26						
		W	2 V		85						ns
			4.5 V		28						
			6 V		24						
t <sub>pd</sub>	S0, S1, S2	Y	2 V		100						ns
			4.5 V		32						
			6 V		27						
		W	2 V		90						ns
			4.5 V		30						
			6 V		26						
t <sub>pd</sub>	$\overline{\text{SC}}$	Y	2 V		80						ns
			4.5 V		26						
			6 V		22						
		W	2 V		80						ns
			4.5 V		26						
			6 V		22						
t <sub>en</sub>	$\overline{\text{G}}1, \overline{\text{G}}2$	Y	2 V		75						ns
			4.5 V		24						
			6 V		20						
		W	2 V		75						ns
			4.5 V		24						
			6 V		20						
t <sub>dis</sub>	$\overline{\text{G}}1, \overline{\text{G}}2$	Y	2 V		45						ns
			4.5 V		15						
			6 V		13						
		W	2 V		45						ns
			4.5 V		15						
			6 V		13						
t <sub>en</sub>	G3	Y	2 V		75						ns
			4.5 V		24						
			6 V		20						
		W	2 V		75						ns
			4.5 V		24						
			6 V		20						
t <sub>dis</sub>	G3	Y	2 V		50						ns
			4.5 V		17						
			6 V		15						
		W	2 V		50						ns
			4.5 V		17						
			6 V		15						

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	40 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

- Inputs are TTL-Voltage Compatible
- 8 High-Current Latches in a Single Package
- High-Current 3-State True Outputs Can Drive up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

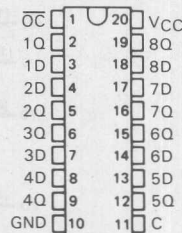
The eight latches of the 'HCT373 are transparent D-type latches. While the enable (C) is high the Q outputs will follow the data (D) inputs. When the enable is taken low, the Q outputs will be latched at the levels that were set up at the D inputs.

An output-control input ( $\overline{OC}$ ) can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

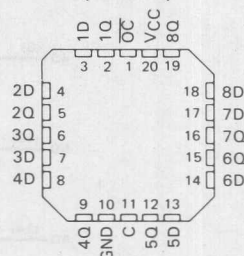
The output control  $\overline{OC}$  does not affect the internal operations of the latches. Old data can be retained or new data can be entered while the outputs are off.

The SN54HCT373 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT373 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

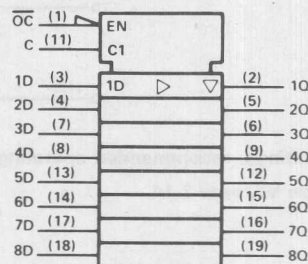
SN54HCT373 ... J PACKAGE  
SN74HCT373 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT373 ... FH OR FK PACKAGE  
(TOP VIEW)



#### logic symbol

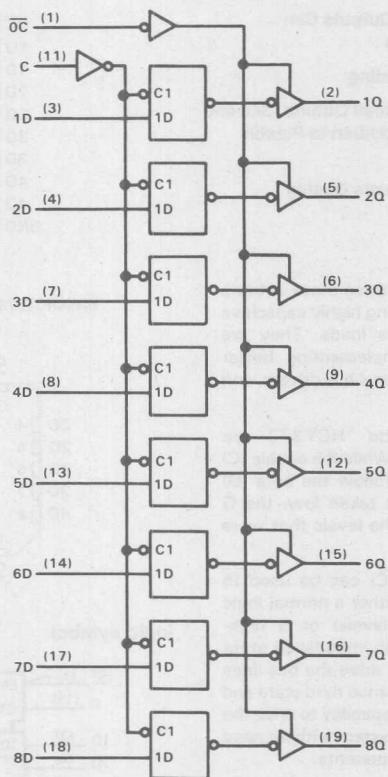


FUNCTION TABLE (EACH LATCH)

INPUTS			OUTPUT
$\overline{OC}$	ENABLE C	D	Q
L	H	H	H
L	H	L	L
L	L	X	$Q_0$
H	X	X	Z

# **TYPES SN54HCT373, SN74HCT373** **OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

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ADVANCE INFORMATION



# **TYPES SN54HCT373, SN74HCT373** **OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT373		SN74HCT373		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	4.5 V	20		30		25		ns
	5.5 V	17		27		23		
t <sub>su</sub> Setup time, data before enable C ↓	4.5 V	10		15		13		ns
	5.5 V	9		14		12		
t <sub>h</sub> Hold time, data after enable C ↓	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT373		SN74HCT373		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q	4.5 V		25	35		53		44	ns
			5.5 V		21	32		48		40	
t <sub>pd</sub>	C	Any Q	4.5 V		28	35		53		44	ns
			5.5 V		25	32		48		40	
t <sub>en</sub>	$\overline{OC}$	Any Q	4.5 V		26	35		53		44	ns
			5.5 V		23	32		48		40	
t <sub>dis</sub>	$\overline{OC}$	Any Q	4.5 V		23	35		53		44	ns
			5.5 V		22	32		48		40	
t <sub>t</sub>		Any	4.5 V		10	12		18		15	ns
			5.5 V		9	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT373			SN74HCT373			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>pd</sub>	D	Q	4.5 V		32	52			79			65	ns
			5.5 V		27	47			71			59	
t <sub>pd</sub>	C	Any Q	4.5 V		38	52			79			65	ns
			5.5 V		36	47			71			59	
t <sub>en</sub>	$\overline{OC}$	Any Q	4.5 V		33	52			79			65	ns
			5.5 V		28	47			71			59	
t <sub>t</sub>		Any	4.5 V		18	42			63			53	ns
			5.5 V		16	38			57			48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

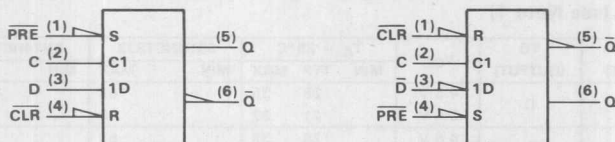
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ADVANCE INFORMATION

## TYPES SN54HCT373, SN74HCT373 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

### D latch signal conventions

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a Q output to go high or a Q output to go low is called Clear. Bars are used over these pin names (PRE and  $\bar{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input D. In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input D, but now both are considered active low.

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ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT374, SN74HCT374 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs Are TTL-Voltage Compatible
- 8 D-Type Flip-Flops in a Single Package
- High-Current 3-State True Outputs Can Drive Up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit flip-flops feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

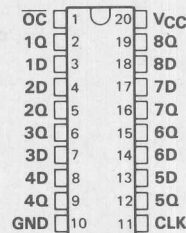
The eight flip-flops of the 'HCT374 are edge-triggered D-type flip-flops. On the positive transition of the clock the Q outputs will be set to the logic levels that were set up at the D inputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

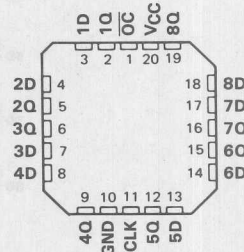
The output control ( $\overline{OC}$ ) does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

The SN54HCT374 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT374 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT374... J PACKAGE  
SN74HCT374... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



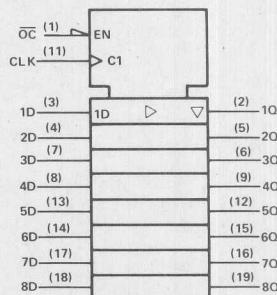
SN54HCT374... FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE (EACH FLIP-FLOP)

INPUTS			OUTPUT
$\overline{OC}$	CLK	D	Q
L	↑	H	H
L	↑	L	L
L	L	X	$Q_0$
H	X	X	Z

### logic symbol

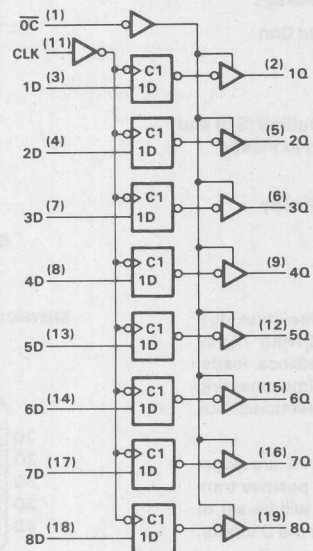


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logic diagram (positive logic)



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ADVANCE INFORMATION

# TYPES SN54HCT374, SN74HCT374 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HCT374		SN74HCT374		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	4.5 V	0	31	0	21	0	25	MHz
	5.5 V	0	36	0	23	0	28	
t <sub>w</sub> Pulse duration, CLK high or low	4.5 V	16		24		20		ns
	5.5 V	14		22		18		
t <sub>su</sub> Setup time, data before CLK ↑	4.5 V	20		30		25		ns
	5.5 V	17		27		23		
t <sub>h</sub> Hold time, data after CLK ↑	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT374		SN74HCT374		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			4.5 V	31	36		21		25		MHz
			5.5 V	36	40		23		28		
t <sub>pd</sub>	CLK	Any	4.5 V		30			54		45	ns
			5.5 V		25			48		41	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		26			45		38	ns
			5.5 V		23			41		34	
t <sub>dis</sub>	$\overline{OC}$	Any	4.5 V		23			45		38	ns
			5.5 V		22			41		34	
t <sub>t</sub>		Any	4.5 V		10			18		15	ns
			5.5 V		9			16		14	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	85 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT374		SN74HCT374		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CLK	Any	4.5 V		40	53		80		66	ns
			5.5 V		35	47		71		60	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		34	47		71		59	ns
			5.5 V		29	39		59		49	
t <sub>t</sub>		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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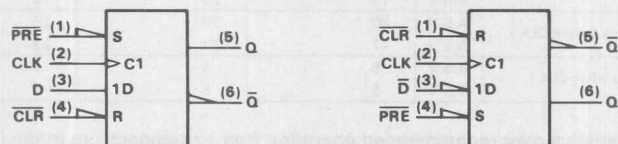
ADVANCE INFORMATION

# **TYPES SN54HCT374, SN74HCT374** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS** **WITH 3-STATE OUTPUTS**

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

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ADVANCE INFORMATION



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC375, SN74HC375 4-BIT BISTABLE LATCHES

D2804, MARCH 1984

- Supply Voltage and Ground on Corner Pins to Simplify PC-Board Layout
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

The SN54HC375 and SN74HC375 bistable latches are electrically and functionally identical to the SN54HC75 and SN74HC75, respectively. Only the arrangement of the terminals has been changed in the SN54HC375 and SN74HC375.

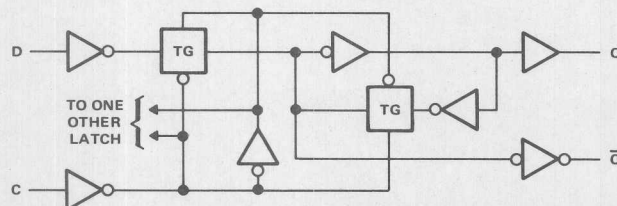
These latches are ideally suited for use as temporary storage for binary information between processing units and input/output or indicator units. Information present at a data (D) input is transferred to the Q output when the enable (C) is high and the Q output will follow the data input as long as the enable remains high. When the enable goes low, the information (that was present at the data input at the time the transition occurred) is retained at the Q output until the enable goes high.

The SN54HC375 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC375 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

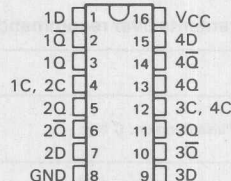
FUNCTION TABLE  
(EACH LATCH)

INPUTS		OUTPUTS	
D	C	Q	$\bar{Q}$
L	H	L	H
H	H	H	L
X	L	$Q_0$	$\bar{Q}_0$

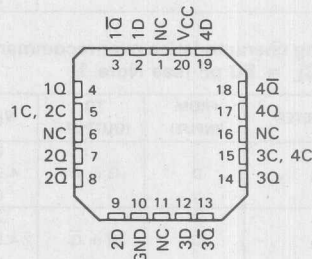
## logic diagram (positive logic)



SN54HC375...J PACKAGE  
SN74HC375...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

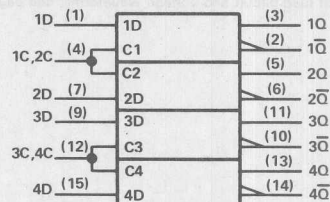


SN54HC375...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

## logic symbol



Pin numbers shown are for J and N packages.

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ADVANCE INFORMATION

# TYPES SN54HC375, SN74HC375 4-BIT BISTABLE LATCHES

absolute maximum ratings, recommended operating conditions, electrical characteristics

See Table II, page 2-6.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC375		SN74HC375		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before C ↓	2 V	100		150		125		ns
	4.5 V	20		30		25		
	6 V	17		26		21		
t <sub>h</sub> Hold time, data after C ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC375		SN74HC375		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	Q or $\bar{Q}$	2 V		40	120		180		150	ns
			4.5 V		14	24		36		30	
			6 V		11	20		31		26	
t <sub>pd</sub>	C	Q or $\bar{Q}$	2 V		42	130		195		165	ns
			4.5 V		15	26		39		33	
			6 V		12	22		33		28	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC533, SN74HC533 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8 Latches in a Single Package
- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

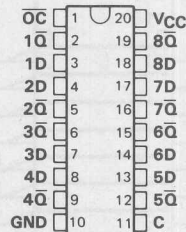
The eight latches of the 'HC533 are transparent D-type latches. While the enable (C) is high, the  $\bar{Q}$  outputs will follow the complements of the D inputs. When the enable is taken low, the  $\bar{Q}$  outputs will be latched at the inverses of the levels that were set up at the D inputs. The 'HC533 is functionally equivalent to the 'HC373 except for having inverted outputs.

An output-control ( $\overline{OC}$ ) input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

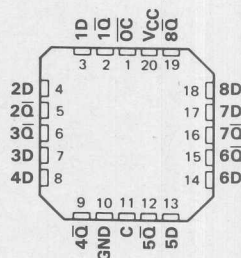
The output control does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are off.

The SN54HC533 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC533 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC533... J PACKAGE  
SN74HC533... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC533... FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE (EACH LATCH)

INPUTS			OUTPUT
$\overline{OC}$	ENABLE C	D	$\bar{Q}$
L	H	H	L
L	H	L	H
L	L	X	$\bar{Q}_0$
H	X	X	Z

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ADVANCE INFORMATION

ADVANCE INFORMATION  
This document contains information  
on a new product. Specifications are  
subject to change without notice.

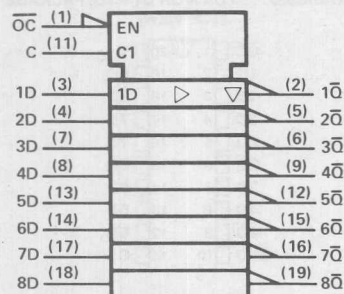
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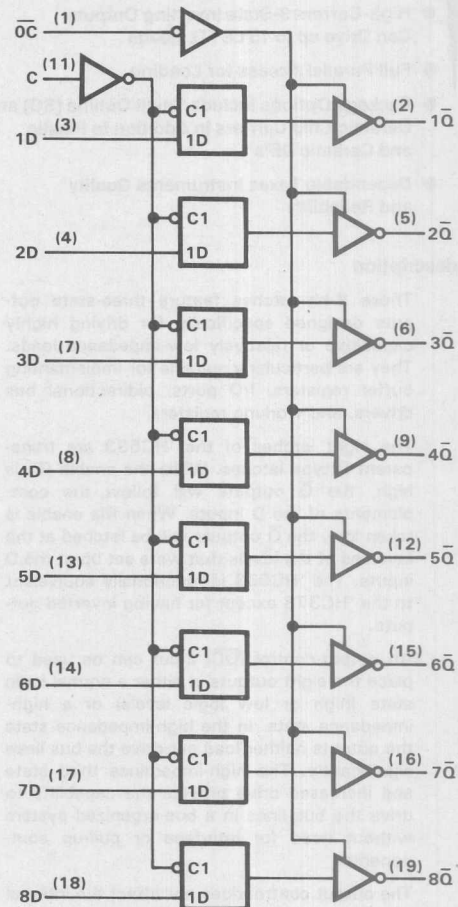
4-61

**TYPES SN54HC533, SN74HC533**  
**OCTAL D-TYPE TRANSPARENT LATCHES**  
**WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



4

ADVANCE INFORMATION

**TYPES SN54HC533, SN74HC533  
OCTAL D-TYPE TRANSPARENT LATCHES  
WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	VCC	T <sub>A</sub> = 25°C		SN54HC533		SN74HC533		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, data before enable C ↓	2 V	50		75		63		ns
	4.5 V	10		15		13		
	6 V	9		13		11		
t <sub>h</sub> Hold time, data after enable C ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	VCC	T <sub>A</sub> = 25°C			SN54HC533		SN74HC533		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	$\bar{Q}$	2 V		77	175		265		220	ns
			4.5 V		26	35		53		44	
			6 V		23	30		45		38	
t <sub>pd</sub>	C	Any	2 V		87	175		265		220	ns
			4.5 V		27	35		53		44	
			6 V		23	30		45		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		68	150		225		190	ns
			4.5 V		24	30		45		38	
			6 V		21	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		47	150		225		190	ns
			4.5 V		23	30		45		38	
			6 V		21	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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NOTE 1: For load circuits and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

# **TYPES SN54HC533, SN74HC533** **OCTAL D-TYPE TRANSPARENT LATCHES** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

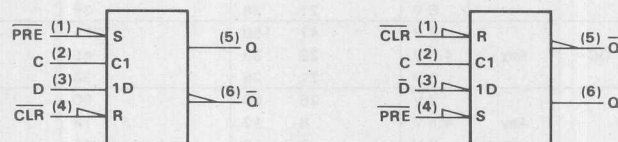
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC533		SN74HC533		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	D	$\bar{Q}$	2 V		95	200		300		250	ns
			4.5 V		33	40		60		50	
			6 V		21	34		51		43	
$t_{pd}$	C	Any	2 V		103	225		335		285	ns
			4.5 V		33	45		67		57	
			6 V		29	38		57		48	
$t_{en}$	$\overline{OC}$	Any	2 V		85	200		300		250	ns
			4.5 V		29	40		60		50	
			6 V		26	34		51		43	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		33		45	

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

## **D latch signal conventions**

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\triangle$  ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT533, SN74HCT533 OCTAL D-TYPE TRANSPARENT LATCHES WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs Are TTL-Voltage Compatible
- 8 Latches in a Single Package
- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Full Parallel Access for Loading
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit latches feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

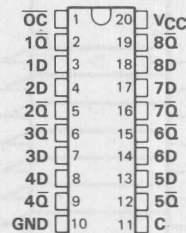
The eight latches of the 'HCT533 are transparent D-type latches. While the enable (C) is high, the  $\bar{Q}$  outputs will follow the complements of the D inputs. When the enable is taken low, the  $\bar{Q}$  outputs will be latched at the inverses of the levels that were set up at the D inputs. The 'HCT533 is functionally equivalent to the 'HCT373 except for having inverted outputs.

An output-control ( $\bar{OC}$ ) input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

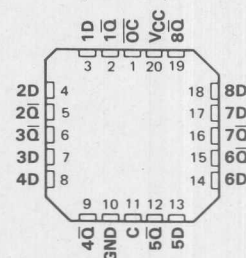
The output control does not affect the internal operation of the latches. Old data can be retained or new data can be entered while the outputs are off.

The SN54HCT533 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT533 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT533... J PACKAGE  
SN74HCT533... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT533... FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE (EACH LATCH)

INPUTS			OUTPUT
$\bar{OC}$	ENABLE C	D	
L	H	H	L
L	H	L	H
L	L	X	$\bar{Q}_0$
H	X	X	Z

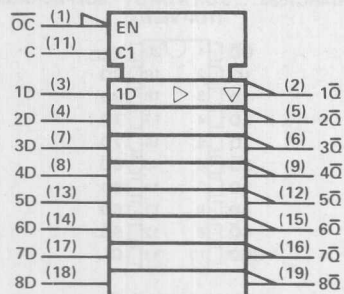
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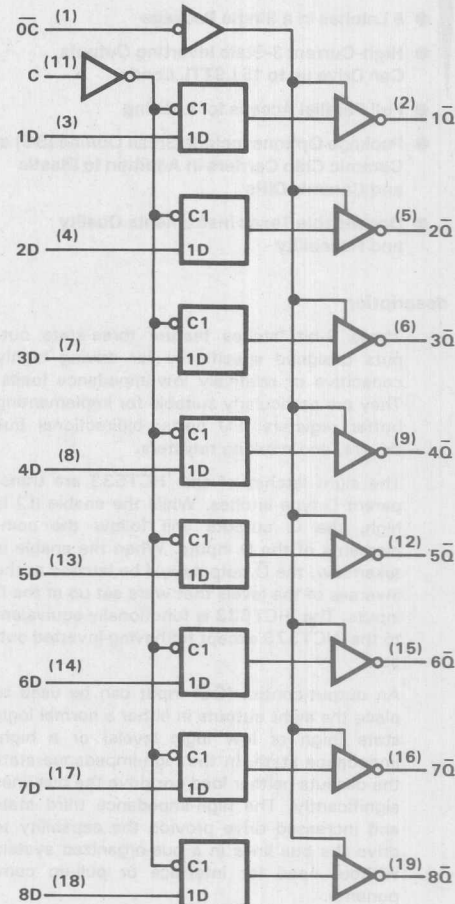
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**TYPES SN54HCT533, SN74HCT533**  
**OCTAL D-TYPE TRANSPARENT LATCHES**  
**WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



**4**

**ADVANCE INFORMATION**

**TYPES SN54HCT533, SN74HCT533  
OCTAL D-TYPE TRANSPARENT LATCHES  
WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	VCC	T <sub>A</sub> = 25°C		SN54HCT533		SN74HCT533		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, enable C high	4.5 V	20		30		25		ns
	5.5 V	17		27		23		
t <sub>su</sub> Setup time, data before enable C ↓	4.5 V	10		15		13		ns
	5.5 V	9		14		12		
t <sub>h</sub> Hold time, data after enable C ↓	4.5 V	5		5		5		ns
	5.5 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	VCC	T <sub>A</sub> = 25°C			SN54HCT533		SN74HCT533		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	$\overline{Q}$	4.5 V		38	35		53		44	ns
			5.5 V		24	32		48		40	
t <sub>pd</sub>	C	Any	4.5 V		30	35		53		44	ns
			5.5 V		28	32		48		40	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		29	35		53		44	ns
			5.5 V		25	32		48		40	
t <sub>dis</sub>	$\overline{OC}$	Any	4.5 V		25	35		53		44	ns
			5.5 V		24	32		48		40	
t <sub>t</sub>		Any	4.5 V		10	12		18		15	ns
			5.5 V		9	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per latch	No load, T <sub>A</sub> = 25°C	50 pF typ
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switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	VCC	T <sub>A</sub> = 25°C			SN54HCT533		SN74HCT533		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	D	$\overline{Q}$	4.5 V		36	52		79		65	ns
			5.5 V		32	47		71		59	
t <sub>pd</sub>	C	Any	4.5 V		40	52		79		65	ns
			5.5 V		38	47		71		59	
t <sub>en</sub>	$\overline{OC}$	Any	4.5 V		35	52		79		65	ns
			5.5 V		29	47		71		59	
t <sub>t</sub>		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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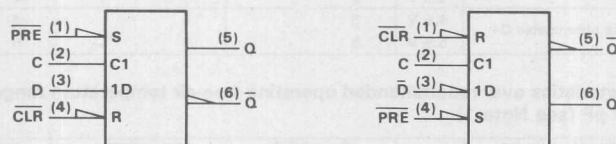
ADVANCE INFORMATION

# **TYPES SN54HCT533, SN74HCT533** **OCTAL D-TYPE TRANSPARENT LATCHES** **WITH 3-STATE OUTPUTS**

## **D latch signal conventions**

It is TI practice to name the outputs and other inputs of a D-type latch and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q, and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

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ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC534, SN74HC534 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit flip-flops feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly attractive for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

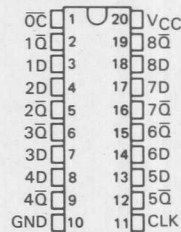
The eight flip-flops of the 'HC534 are edge-triggered D-type flip-flops. On the positive transition of the clock, the  $\bar{Q}$  outputs will be set to the complement of the logic states that were set up at the D inputs. The 'HC534 is functionally equivalent to the 'HC374 except for having inverted outputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

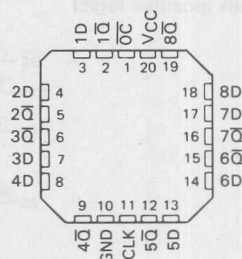
The output control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are off.

The SN54HC534 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC534 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC534 ... J PACKAGE  
SN74HC534 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC534 ... FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE (EACH FLIP-FLOP)

INPUTS			OUTPUT
$\bar{O}C$	CLK	D	$\bar{Q}$
L	↑	H	L
L	↑	L	H
L	L	X	$\bar{Q}_0$
H	X	X	Z

### ADVANCE INFORMATION

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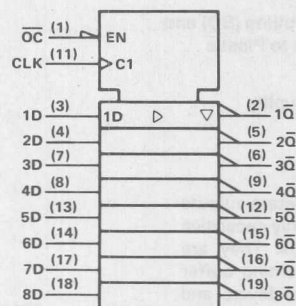
4-69

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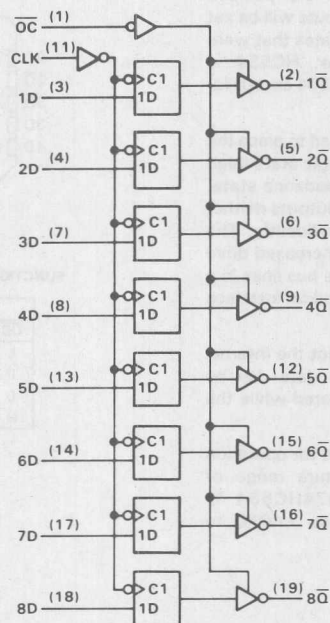
ADVANCE INFORMATION

**TYPES SN54HC534, SN74HC534**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS**  
**WITH 3-STATE OUTPUTS**

logic symbol



logic diagram (positive logic)



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ADVANCE INFORMATION



**TYPES SN54HC534, SN74HC534**  
**OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS**  
**WITH 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC534		SN74HC534		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	6	0	4.2	0	5	MHz
			4.5 V	0	31	0	21	0	25	
			6 V	0	36	0	25	0	29	
t <sub>w</sub>	Pulse duration	CLK high or low	2 V	80		120		100		ns
			4.5 V	16		24		20		
			6 V	14		20		17		
t <sub>su</sub>	Setup time, data before CLK ↑		2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
t <sub>h</sub>	Hold time, data after CLK ↑		2 V	5		5		5		ns
			4.5 V	5		5		5		
			6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC534		SN74HC534		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	11		4.2		5		MHz
			4.5 V	31	36		21		25		
			6 V	36	40		25		29		
t <sub>pd</sub>	CLK	Any	2 V		88	180		270		225	ns
			4.5 V		28	36		54		45	
			6 V		24	31		46		38	
t <sub>en</sub>	$\overline{OC}$	Any	2 V		77	150		225		190	ns
			4.5 V		26	30		45		38	
			6 V		23	26		38		32	
t <sub>dis</sub>	$\overline{OC}$	Any	2 V		51	150		225		190	ns
			4.5 V		25	30		45		38	
			6 V		23	26		38		32	
t <sub>t</sub>		Any	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

C <sub>pd</sub>	Power dissipation per flip-flop	No load, T <sub>A</sub> = 25°C	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

# **TYPES SN54HC534, SN74HC534** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS** **WITH 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

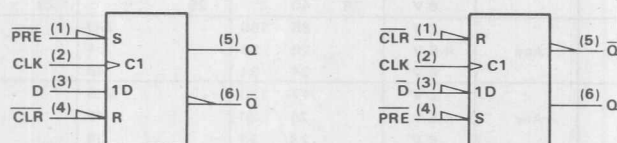
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC534		SN74HC534		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CLK	Any	2 V		105	230		345		290	ns
			4.5 V		35	46		69		58	
			6 V		31	39		58		49	
$t_{en}$	$\overline{OC}$	Any	2 V		95	200		300		250	ns
			4.5 V		32	40		60		50	
			6 V		29	34		51		43	
$t_t$		Any	2 V		60	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		14	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\overline{Q}$ . An input that causes a Q output to go high or a  $\overline{Q}$  output to go low is called Preset; an input that causes a  $\overline{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names ( $\overline{PRE}$  and  $\overline{CLR}$ ) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\overline{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\overline{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators ( $\nabla$ ) on  $\overline{PRE}$  and  $\overline{CLR}$  remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\overline{D}$ , Q and  $\overline{Q}$ . Of course pin 5 ( $\overline{Q}$ ) is still in phase with the data input  $\overline{D}$ , but now both are considered active-low.

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ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT534, SN74HCT534 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- High-Current 3-State Inverting Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These 8-bit flip-flops feature three-state outputs designed specifically for driving highly capacitive or relatively low-impedance loads. They are particularly attractive for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

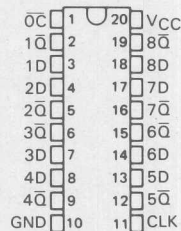
The eight flip-flops of the 'HCT534 are edge-triggered D-type flip-flops. On the positive transition of the clock, the  $\bar{Q}$  outputs will be set to the complement of the logic states that were set up at the D inputs. The 'HCT534 is functionally equivalent to the 'HCT374 except for having inverted outputs.

An output-control input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly. The high-impedance third state and increased drive provide the capability to drive the bus lines in a bus-organized system without need for interface or pull-up components.

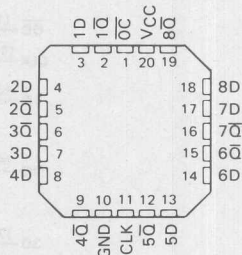
The output control does not affect the internal operation of the flip-flops. Old data can be retained or new data can be entered while the outputs are off.

The SN54HCT534 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT534 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT534 . . . J PACKAGE  
SN74HCT534 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT534 . . . FH OR FK PACKAGE  
(TOP VIEW)



FUNCTION TABLE (EACH FLIP-FLOP)

INPUTS			OUTPUT
$\bar{O}C$	CLK	D	$\bar{Q}$
L	↑	H	L
L	↑	L	H
L	L	X	$\bar{Q}_0$
H	X	X	Z

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ADVANCE INFORMATION

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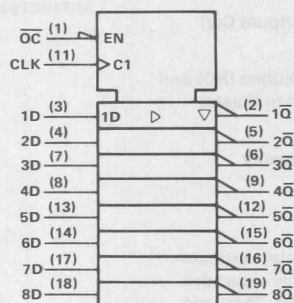
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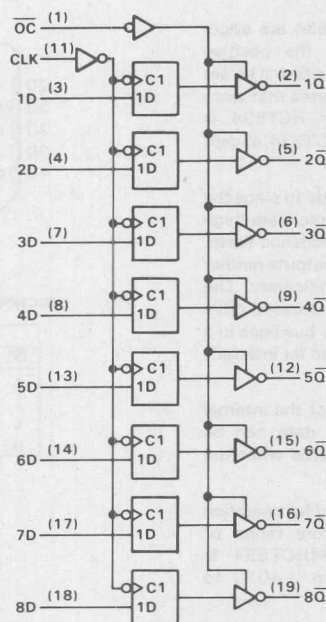
4-73

# TYPES SN54HCT534, SN74HCT534 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

logic symbol



logic diagram (positive logic)



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ADVANCE INFORMATION

# TYPES SN54HCT534, SN74HCT534 OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS WITH 3-STATE OUTPUTS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HCT534		SN74HCT534		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	4.5 V	0	31	0	21	0	25	MHz
		5.5 V	0	36	0	23	0	28	
t <sub>w</sub>	Pulse duration	4.5 V	16		24		20		ns
		5.5 V	14		22		18		
	CLK low	4.5 V	16		24		20		ns
		5.5 V	14		22		18		
t <sub>su</sub>	Setup time, data before CLK ↑	4.5 V	20		30		25		ns
		5.5 V	17		27		23		
t <sub>h</sub>	Hold time, data after CLK ↑	4.5 V	5		5		5		ns
		5.5 V	5		5		5		

switching characteristics, over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT534		SN74HCT534		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			4.5 V	31	36		21		25		MHz
			5.5 V	36	40		23		28		
t <sub>pd</sub>	CLK	Any	4.5 V		28	36		54		45	ns
			5.5 V		26	32		48		41	
t <sub>en</sub>	$\overline{\text{OC}}$	Any	4.5 V		24	30		45		38	ns
			5.5 V		20	27		41		34	
t <sub>dis</sub>	$\overline{\text{OC}}$	Any	4.5 V		22	30		45		38	ns
			5.5 V		20	27		41		34	
t <sub>t</sub>		Any	4.5 V		10	12		18		15	ns
			5.5 V		9	11		16		14	

C <sub>pd</sub>	Power dissipation capacitance per flip-flop	No load, T <sub>A</sub> = 25 °C	93 pF typ
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switching characteristics, over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 150 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT534		SN74HCT534		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CLK	Any	4.5 V		38	53		80		66	ns
			5.5 V		36	47		71		60	
t <sub>en</sub>	$\overline{\text{OC}}$	Any	4.5 V		30	47		71		59	ns
			5.5 V		27	39		59		49	
t <sub>t</sub>		Any	4.5 V		18	42		63		53	ns
			5.5 V		16	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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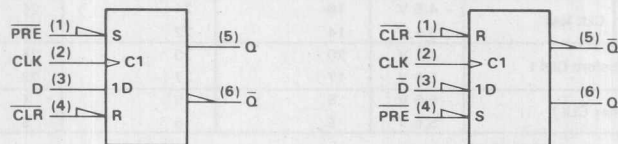
ADVANCE INFORMATION

# **TYPES SN54HCT534, SN74HCT534** **OCTAL D-TYPE EDGE-TRIGGERED FLIP-FLOPS** **WITH 3-STATE OUTPUTS**

## **D flip-flop signal conventions**

It is TI practice to name the outputs and other inputs of a D-type flip-flop and to draw its logic symbol based on the assumption of true data (D) inputs. Then outputs that produce data in phase with the data inputs are called Q and those producing complementary data are called  $\bar{Q}$ . An input that causes a Q output to go high or a  $\bar{Q}$  output to go low is called Preset; an input that causes a  $\bar{Q}$  output to go high or a Q output to go low is called Clear. Bars are used over these pin names (PRE and CLR) if they are active-low.

In some applications it may be advantageous to redesignate the data input  $\bar{D}$ . In that case all the other inputs and outputs should be renamed as shown below. Also shown are corresponding changes in the graphical symbol. Arbitrary pin numbers are shown in parentheses.



Notice that Q and  $\bar{Q}$  exchange names, which causes Preset and Clear to do likewise. Also notice that the polarity indicators (  $\nabla$  ) on PRE and CLR remain since these inputs are still active-low, but that the presence or absence of the polarity indicator changes at  $\bar{D}$ , Q and  $\bar{Q}$ . Of course pin 5 ( $\bar{Q}$ ) is still in phase with the data input  $\bar{D}$ , but now both are considered active-low.

## **4**

## **ADVANCE INFORMATION**



- High-Current 3-State Outputs Drive Bus Lines Directly or up to 15 LSTTL Loads
- Data Flow-Thru Pinout (All Inputs on Opposite Side from Outputs)
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

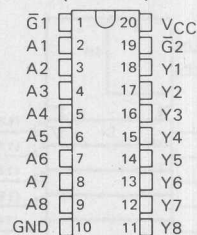
These octal buffers and line drivers are designed to have the performance of the popular SN54HC240/SN74HC240 series and, at the same time, offer a pinout with inputs and outputs on opposite sides of the package. This arrangement greatly enhances printed circuit board layout.

The three-state control gate is a 2-input NOR such that if either G1 or G2 is high, all eight outputs are in the high-impedance state.

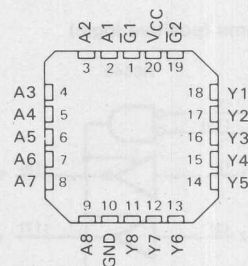
The 'HC540 provides inverted data and the 'HC541 provides true data at the outputs.

The SN54HC540 and SN54HC541 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC540 and SN74HC541 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

#### SN54HC540, SN54HC541 ... J PACKAGE SN74HC540, SN74HC541 ... J OR N OR D (= SO) PACKAGE (TOP VIEW)



#### SN54HC540, SN54HC541 ... FH OR FK PACKAGE (TOP VIEW)



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ADVANCE INFORMATION

#### ADVANCE INFORMATION

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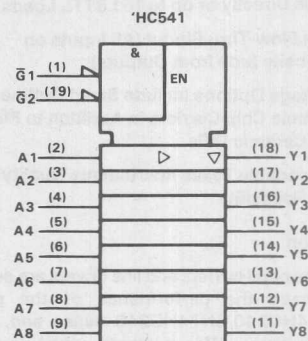
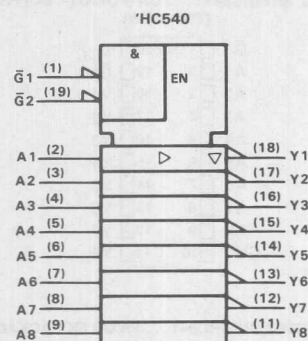
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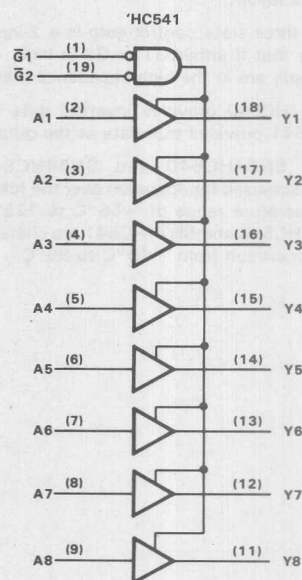
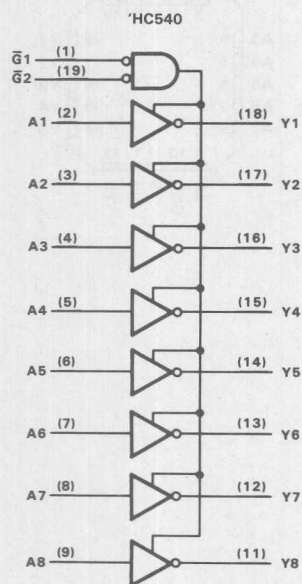
4-77

**TYPES SN54HC540, SN54HC541  
SN74HC540, SN74HC541  
OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

**logic symbols**



**logic diagrams (positive logic)**



**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

**4**

**ADVANCE INFORMATION**

# **TYPES SN54HC540, SN74HC540** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

'HC540 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC540		SN74HC540		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		35	100		149		126	ns
			4.5 V		10	20		30		25	
			6 V		8	17		25		21	
$t_{en}$	$\overline{G}$	Y	2 V		75	150		224		189	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{dis}$	$\overline{G}$	Y	2 V		40	150		224		189	ns
			4.5 V		18	30		45		38	
			6 V		17	26		38		32	
$t_t$		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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'HC540 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC540		SN74HC540		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		60	150		224		190	ns
			4.5 V		15	30		45		38	
			6 V		13	26		38		32	
$t_{en}$	$\overline{G}$	Y	2 V		100	200		298		252	ns
			4.5 V		20	40		60		50	
			6 V		17	34		51		43	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

'HC541 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC541		SN74HC541		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		40	115		171		145	ns
			4.5 V		12	23		34		29	
			6 V		10	20		29		25	
$t_{en}$	$\overline{G}$	Y	2 V		80	150		224		189	ns
			4.5 V		17	30		45		38	
			6 V		15	26		38		32	
$t_{dis}$	$\overline{G}$	Y	2 V		40	150		224		189	ns
			4.5 V		18	30		45		38	
			6 V		17	26		38		32	
$t_t$		Y	2 V		28	60		90		75	ns
			4.5 V		8	12		18		15	
			6 V		6	10		15		13	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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'HC541 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC541		SN74HC541		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	2 V		55	165		246		208	ns
			4.5 V		16	33		49		42	
			6 V		14	28		42		35	
$t_{en}$	$\overline{G}$	Y	2 V		100	200		298		252	ns
			4.5 V		20	40		60		50	
			6 V		17	34		51		43	
$t_t$		Y	2 V		45	210		315		265	ns
			4.5 V		17	42		63		53	
			6 V		13	36		53		45	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HCT540, SN54HCT541 SN74HCT540, SN74HCT541 OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Inputs are TTL-Voltage Compatible
- High-Current 3-State Outputs Interface Directly with System Bus or Can Drive up to 15 LSTTL Loads
- Data Flow-Thru Pinout (All Inputs on Opposite Side from Outputs)
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

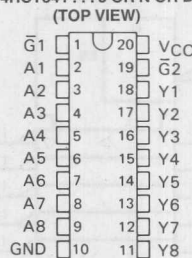
These octal buffers and line drivers are designed to have the performance of the popular SN54HCT240/SN74HCT240 series and, at the same time, offer a pinout with inputs and outputs on opposite sides of the package. This arrangement greatly enhances printed circuit board layout.

The three-state control gate is a 2-input NOR such that if either  $\bar{G}1$  or  $\bar{G}2$  is high, all eight outputs are in the high-impedance state.

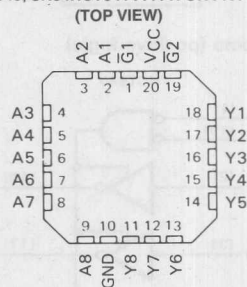
The 'HCT540 provides inverted data and the 'HCT541 provides true data at the outputs.

The SN54HCT540 and SN54HCT541 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT540 and SN74HCT541 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT540, SN54HCT541 ... J PACKAGE  
SN74HCT540, SN74HCT541 ... J OR N OR D (= SO) PACKAGE



SN54HCT540, SN54HCT541 ... FH OR FK PACKAGE



4

ADVANCE INFORMATION

#### ADVANCE INFORMATION

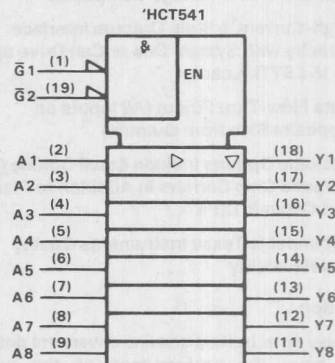
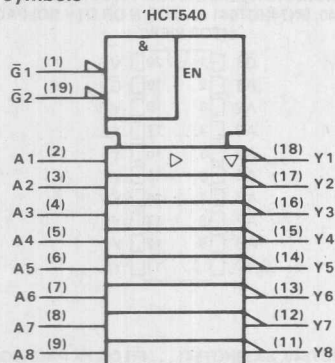
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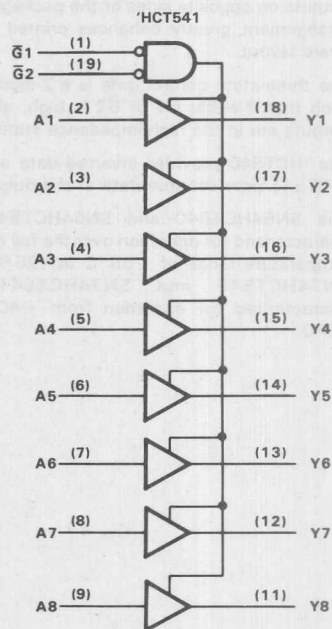
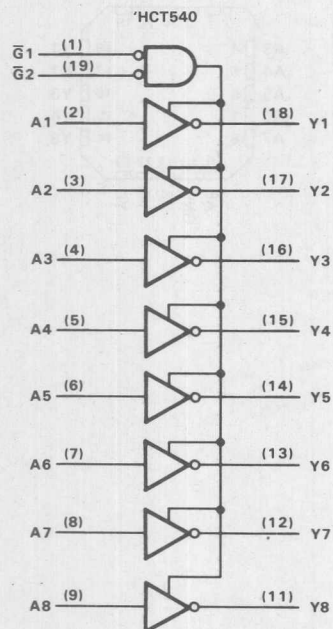
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**TYPES SN54HCT540, SN54HCT541  
SN74HCT540, SN74HCT541  
OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

logic symbols



logic diagrams (positive logic)



4

ADVANCE INFORMATION

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.



# **TYPES SN54HCT540, SN74HCT540** **OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS**

'HCT540 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT540		SN74HCT540		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		13	20		30		25	ns
			5.5 V		12	20		30		25	
$t_{en}$	$\overline{G}$	Y	4.5 V		20	30		45		38	ns
			5.5 V		18	30		45		38	
$t_{dis}$	$\overline{G}$	Y	4.5 V		19	30		45		38	ns
			5.5 V		18	30		45		38	
$t_t$		Y	4.5 V		8	12		18		15	ns
			5.5 V		7	12		18		15	

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	35 pF typ
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'HCT540 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HCT540		SN74HCT540		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A	Y	4.5 V		20	30		45		38	ns
			5.5 V		18	30		45		38	
$t_{en}$	$\overline{G}$	Y	4.5 V		26	40		60		50	ns
			5.5 V		25	40		60		50	
$t_t$		Y	4.5 V		17	42		63		53	ns
			5.5 V		14	42		63		53	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

# TYPES SN54HCT541, SN74HCT541 OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

'HCT541 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT541		SN74HCT541		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	4.5 V		13	23		34		29	ns
			5.5 V		12	23		34		29	
t <sub>en</sub>	$\overline{G}$	Y	4.5 V		21	30		45		38	ns
			5.5 V		19	30		45		38	
t <sub>dis</sub>	$\overline{G}$	Y	4.5 V		19	30		45		38	ns
			5.5 V		18	30		45		38	
t <sub>t</sub>		Y	4.5 V		8	12		18		15	ns
			5.5 V		7	12		18		15	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25 °C	35 pF typ
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'HCT541 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HCT541		SN74HCT541		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A	Y	4.5 V		20	33		49		42	ns
			5.5 V		19	33		49		42	
t <sub>en</sub>	$\overline{G}$	Y	4.5 V		26	40		60		50	ns
			5.5 V		25	40		60		50	
t <sub>t</sub>		Y	4.5 V		17	42		63		53	ns
			5.5 V		14	42		63		53	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC589, SN74HC589 8-BIT SHIFT REGISTERS WITH INPUT LATCHES AND 3-STATE OUTPUTS

D2804, MARCH 1984

- 8-Bit Parallel Storage Inputs
- Parallel 3-Stage I/O Storage Register Inputs, Shift Register Output
- High-Current 3-State Output Can Drive Up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

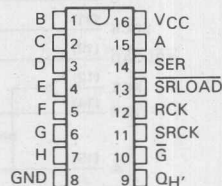
### description

The 'HC589 is similar to 'HC598 but has a three-state output whose control input replaces the direct clear input for the shift register. Like 'HC598, 'HC589 consists of an 8-bit storage register feeding a parallel-in, serial-out 8-bit shift register. Parallel loading of the storage register takes place on the positive-going edge of the RCK signal. If SRLOAD is low, data from the storage register is loaded into the shift register on the positive edge of the SRCK signal. If SRLOAD is high, data in the storage register is shifted one bit with new data entering serially at SER.

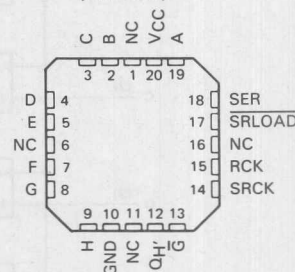
If the output enable  $\bar{G}$  is high, the output is in the high-impedance state, but this does not affect loading, transfer of data from storage, or shifting.

The SN54HC589 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC589 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC589... J PACKAGE  
SN74HC589... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

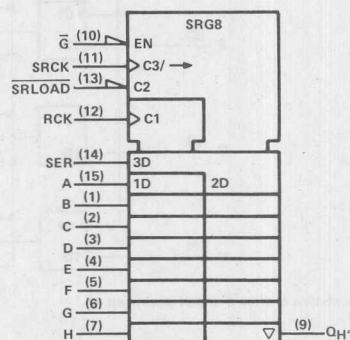


SN54HC589... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

4

ADVANCE INFORMATION

### ADVANCE INFORMATION

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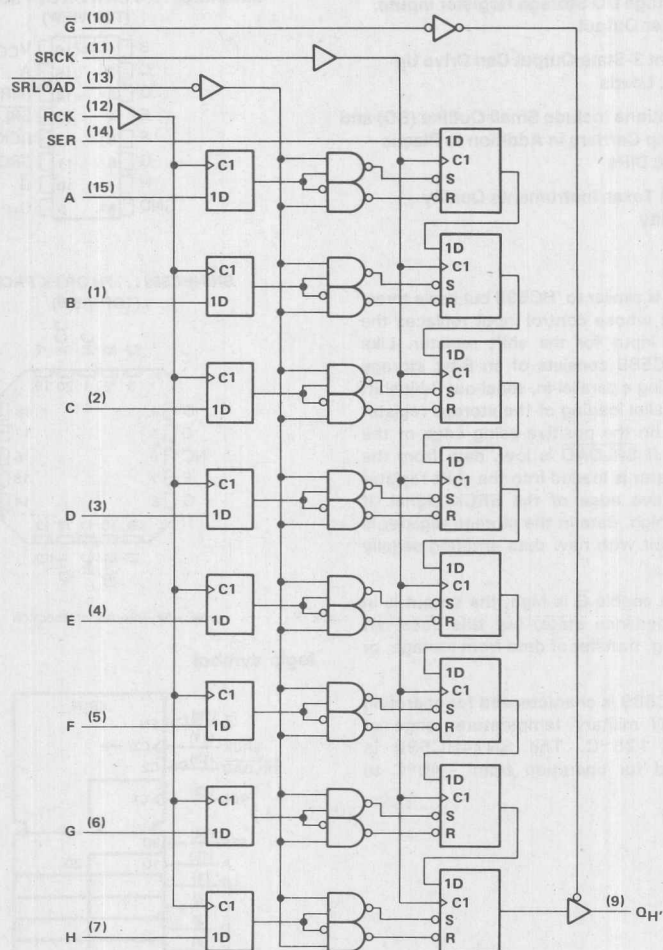
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**TYPES SN54HC589, SN74HC589**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**  
**AND 3-STATE OUTPUTS**

logic diagram (positive logic)



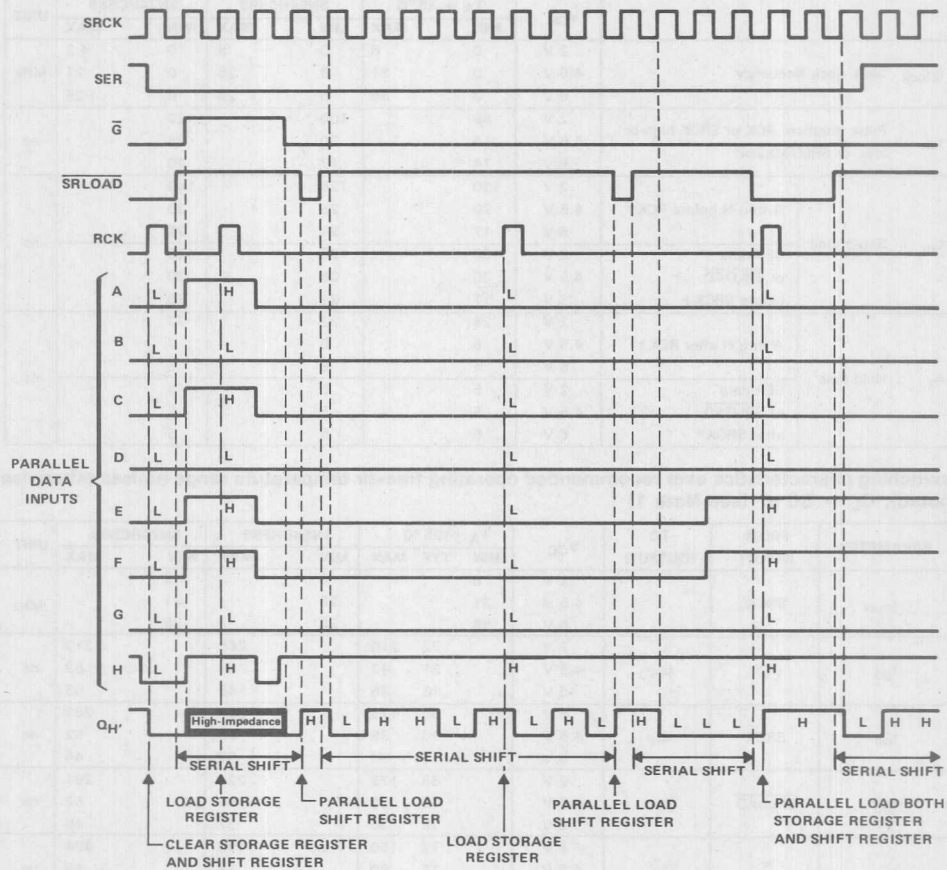
Pin numbers shown are for J and N packages.

4

ADVANCE INFORMATION

**TYPES SN54HC589, SN74HC589**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**  
**AND 3-STATE OUTPUTS**

typical load and shift sequence



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

4

ADVANCE INFORMATION

**TYPES SN54HC589, SN74HC589**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**  
**AND 3-STATE OUTPUTS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC589		SN74HC589		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Shift clock frequency	2 V	0	6	0	5	0	4.2	MHz
		4.5 V	0	31	0	25	0	21	
		6 V	0	36	0	29	0	25	
t <sub>w</sub>	Pulse duration, RCK or SRCK high or low, or SRLOAD low	2 V	80		100		120		ns
		4.5 V	16		20		24		
		6 V	14		17		20		
t <sub>su</sub>	A thru H before RCK ↑	2 V	100		126		149		ns
		4.5 V	20		25		30		
		6 V	17		21		25		
	SER data or SRLOAD before SRCK ↑	2 V	100		126		149		
		4.5 V	20		25		30		
		6 V	17		21		25		
t <sub>h</sub>	A thru H after RCK ↑	2 V	25		32		37		ns
		4.5 V	5		6		7		
		6 V	4		5		6		
	SER data or SRLOAD after SRCK ↑	2 V	5		5		5		
		4.5 V	5		5		5		
		6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54CH589		SN74HC589		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>	SRCK		2 V	6			5		4.2		MHz
			4.5 V	31			25		21		
			6 V	36			29		25		
t <sub>pd</sub>	RCK	Q <sub>H'</sub>	2 V		72	210		265		313	ns
			4.5 V		21	42		53		63	
			6 V		18	36		45		53	
t <sub>pd</sub>	SRCK	Q <sub>H'</sub>	2 V		88	175		221		261	ns
			4.5 V		18	35		44		52	
			6 V		15	30		37		44	
t <sub>pd</sub>	SRLOAD	Q <sub>H'</sub>	2 V		88	175		221		261	ns
			4.5 V		18	35		44		52	
			6 V		15	30		37		44	
t <sub>en</sub>	$\overline{G}$	Q <sub>H'</sub>	2 V		75	150		189		224	ns
			4.5 V		15	30		38		45	
			6 V		13	26		32		38	
t <sub>dis</sub>	$\overline{G}$	Q <sub>H'</sub>	2 V		75	150		189		224	ns
			4.5 V		15	30		38		45	
			6 V		13	26		32		38	
t <sub>t</sub>		Any	2 V		28	60		75		90	ns
			4.5 V		8	12		15		18	
			6 V		6	10		13		15	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



**TYPES SN54HC589, SN74HC589**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**  
**AND 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$		SN54HC589		SN74HC589		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	RCK	$Q_H'$	2 V		260		328		387	ns
			4.5 V		52		66		77	
			6 V		44		56		66	
$t_{pd}$	SRCK	$Q_H'$	2 V		225		284		335	ns
			4.5 V		45		57		67	
			6 V		38		48		57	
$t_{pd}$	$\overline{\text{SRLOAD}}$	$Q_H'$	2 V		225		284		335	ns
			4.5 V		45		57		67	
			6 V		38		48		57	
$t_{en}$	$\overline{G}$	$Q_H'$	2 V		200		252		298	ns
			4.5 V		40		50		60	
			6 V		34		43		51	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# TYPE 240000 - 240000 SHIFT REGISTERS WITH INPUT LATCHES AND STATE OUTPUTS

Operating conditions are as recommended operating conditions for the 240000 series. The 240000 series is designed to operate at a maximum clock rate of 100 MHz.

PARAMETER	UNIT	MIN	TYP	MAX	TEST CONDITIONS
PROPAGATION DELAY	ns	1.5	2.0	2.5	CL = 10 pF
SETUP TIME	ns	1.5	2.0	2.5	CL = 10 pF
HELD TIME	ns	1.5	2.0	2.5	CL = 10 pF
POWER-UP DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-DOWN DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-UP DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-DOWN DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-UP DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-DOWN DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-UP DELAY	ns	1.5	2.0	2.5	CL = 10 pF
POWER-DOWN DELAY	ns	1.5	2.0	2.5	CL = 10 pF

NOTE: 1. The 240000 series is designed to operate at a maximum clock rate of 100 MHz.

## 4

## ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC590, SN74HC590 8-BIT BINARY COUNTERS WITH 3-STATE OUTPUT REGISTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8-Bit Counter with Register
- High-Current 3-State Parallel Register Outputs Can Drive up to 15 LSTTL Loads
- Counter Has Direct Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

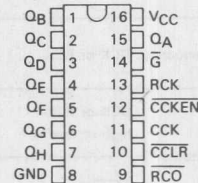
### description

These devices each contain an 8-bit binary counter that feeds an 8-bit storage register. The storage register has parallel outputs. Separate clocks are provided for both the binary counter and storage register. The binary counter features a direct clear input  $\overline{\text{CCLR}}$  and a count enable input  $\overline{\text{CCKEN}}$ . For cascading a ripple carry output  $\overline{\text{RCO}}$  is provided. Expansion is easily accomplished by tying  $\overline{\text{RCO}}$  of the first stage to  $\overline{\text{CCKEN}}$  of the second stage, etc.

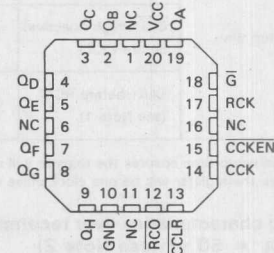
Both the counter and register clocks are positive-edge triggered. If the user wishes to connect both clocks together, the counter state will always be one count ahead of the register. Internal circuitry prevents clocking from the clock enable.

The SN54HC590 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC590 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC590 . . . J PACKAGE  
SN74HC590 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

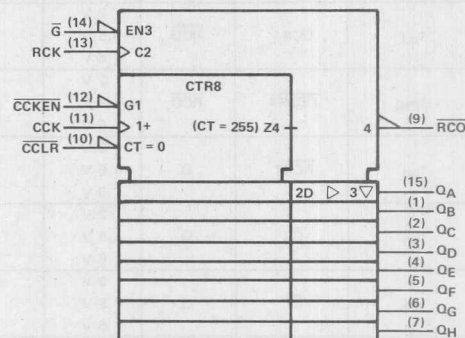


SN54HC590 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

**ADVANCE INFORMATION**  
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**TYPES SN54HC590, SN74HC590**  
**8-BIT BINARY COUNTERS**  
**WITH 3-STATE OUTPUT REGISTERS**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC590		SN74HC590		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency, CCK or RCK	2 V	0	4	0	2.6	0	3.2	MHz
		4.5 V	0	20	0	13	0	16	
		6 V	0	24	0	16	0	19	
t <sub>w</sub>	Pulse duration	2 V	125		190		155		ns
		4.5 V	25		38		31		
		6 V	21		32		26		
	CCLR low	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
t <sub>su</sub>	CCKEN low before CCK↑	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
	CCLR high (inactive) before CCK↑	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
	CLK1 before RCK↑ (see Note 1)	2 V	200		300		250		ns
		4.5 V	40		60		50		
		6 V	34		51		43		

NOTE 1: This setup time ensures the register will see stable data from the counter outputs. The clocks may be tied together in which case the register will be one clock pulse behind the counter.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC590		SN74HC590		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>	CCK or RCK		2 V		4	8	2.6		3.2		MHz
			4.5 V		20	35	13		16		
			6 V		24	40	16		19		
t <sub>pd</sub>	CCK↑	RCO	2 V			75					ns
			4.5 V			25					
			6 V			23					
t <sub>PHL</sub>	CCLR↓	RCO	2 V			90					ns
			4.5 V			30					
			6 V			27					
t <sub>pd</sub>	RCK↑	Q	2 V			75					ns
			4.5 V			25					
			6 V			23					
t <sub>en</sub>	G̅↓	Q	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>dis</sub>	G̅↑	Q	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>t</sub>			2 V			28					ns
			4.5 V			8					
			6 V			6					

NOTE 2: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

- Inputs Are TTL-Voltage Compatible
- Lock Bus-Latch Capability
- Choice of True or Inverting Logic
- High-Current 3-State Outputs Can Drive Up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

DEVICE	LOGIC
'HCT620	Inverting
'HCT623	True

### description

These octal bus transceivers are designed for asynchronous two-way communication between data buses. The control function implementation allows for maximum flexibility in timing.

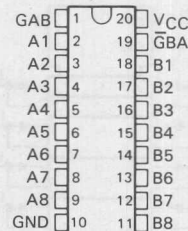
These devices allow data transmission from the A bus to the B bus or from the B bus to the A bus depending upon the logic levels at the enable inputs ( $\overline{\text{GBA}}$  and  $\text{GAB}$ ).

The enable inputs can be used to disable the device so that the buses are effectively isolated.

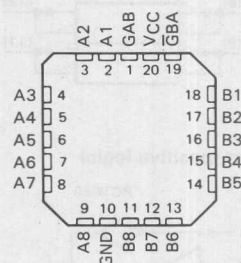
The dual-enable configuration gives these devices the capability to store data by simultaneous enabling of  $\overline{\text{GBA}}$  and  $\text{GAB}$ . Each output reinforces its input in this transceiver configuration. Thus, when both control inputs are enabled and all other data sources to the two sets of bus lines are at high impedance, both sets of bus lines (16 in all) will remain at their last states. The 8-bit codes appearing on the two sets of buses will be identical for the 'HCT623 or complementary for the 'HCT620.

The SN54HCT620 and SN54HCT623 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HCT620 and SN74HCT623 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HCT'...J PACKAGE  
SN74HCT'...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HCT'...FH OR FK PACKAGE  
(TOP VIEW)

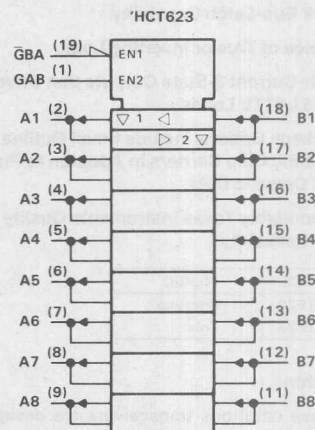
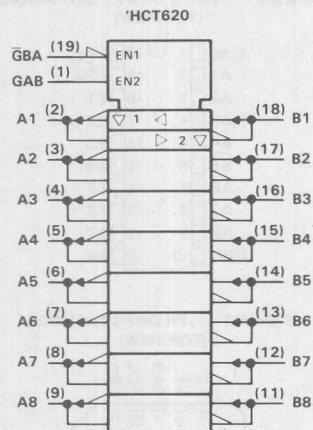


FUNCTION TABLE

ENABLE INPUTS		OPERATION	
$\overline{\text{GBA}}$	$\text{GAB}$	'HCT620	'HCT623
L	L	$\overline{\text{B}}$ data to A bus	B data to A bus
H	H	$\overline{\text{A}}$ data to B bus	A data to B bus
H	L	Isolation	Isolation
L	H	$\overline{\text{B}}$ data to A bus, $\overline{\text{A}}$ data to B bus	B data to A bus, A data to B bus

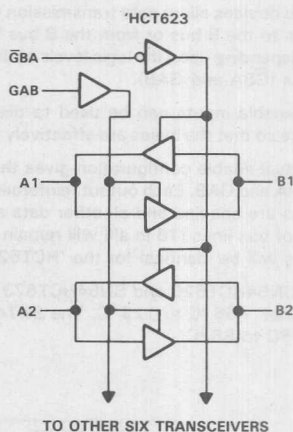
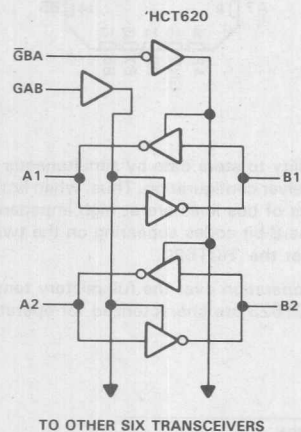
# TYPES SN54HCT620, SN54HCT623, SN74HCT620, SN74HCT623 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

logic symbol



4

logic diagram (positive logic)



ADVANCE INFORMATION



# TYPES SN54HCT620, SN54HCT623, SN74HCT620, SN74HCT623 OCTAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table VII, page 2-14.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT620 SN54HCT623		SN74HCT620 SN74HCT623		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		13	21		32		26	ns
			5.5 V		11	18		27		23	
t <sub>en</sub>	$\overline{\text{G}}$ BA	A	4.5 V		30	42		63		53	ns
			5.5 V		23	38		57		48	
t <sub>dis</sub>	$\overline{\text{G}}$ BA	A	4.5 V		18	30		45		38	ns
			5.5 V		16	28		42		35	
t <sub>en</sub>	GAB	B	4.5 V		30	42		63		53	ns
			5.5 V		23	38		57		48	
t <sub>dis</sub>	GAB	B	4.5 V		18	30		45		38	ns
			5.5 V		16	28		42		35	
t <sub>t</sub>		A or B	4.5 V		9	12		18		15	ns
			5.5 V		8	11		16		14	

C<sub>pd</sub>

Power dissipation capacitance per transceiver

No load, T<sub>A</sub> = 25°C

40 pF typ

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HCT620 SN54HCT623		SN74HCT620 SN74HCT623		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	B or A	4.5 V		18	38		58		47	ns
			5.5 V		11	34		52		42	
t <sub>en</sub>	$\overline{\text{G}}$ BA	A	4.5 V		36	59		89		74	ns
			5.5 V		30	53		80		67	
t <sub>en</sub>	GAB	B	4.5 V		36	59		89		74	ns
			5.5 V		30	53		80		67	
t <sub>t</sub>		A or B	4.5 V		17	42		63		53	ns
			5.5 V		14	38		57		48	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION



**'HC673**

- 16-Bit Serial-In, Serial-Out Shift Register with 16-Bit Parallel-Out Storage Register
- Performs Serial-to-Parallel Conversion

**'HC674**

- 16-Bit Parallel-In, Serial-Out Shift Register
- Performs Parallel-to-Serial Conversion
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

**description**

**SN54HC673, SN74HC673**

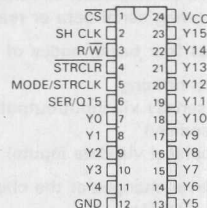
The 'HC673 is a 16-bit shift register and a 16-bit storage register in a single 24-pin package. A three-state input/output (SER/Q15) port to the shift register allows serial entry and/or reading of data. The storage register is connected in a parallel data loop with the shift register and may be asynchronously cleared by taking the store-clear input low. The storage register may be parallel loaded with shift-register data to provide shift-register status via the parallel outputs. The shift register can be parallel loaded with the storage-register data upon command.

A high logic level at the chip-select (CS) input disables both the shift-register clock and the storage-register clock and places SER/Q15 in the high-impedance state. The store-clear function is not disabled by the chip select.

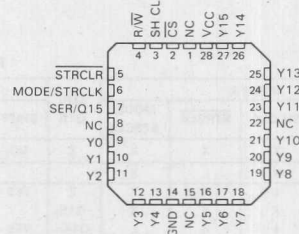
Caution must be exercised to prevent false clocking of either the shift register or the storage register via the chip-select input. The shift clock should be low during the low-to-high transition of chip select and the store clock should be low during the high-to-low transition of chip select.

The SN54HC673 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC673 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**SN54HC673...JT PACKAGE  
SN74HC673...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC673...FH OR FK PACKAGE  
(TOP VIEW)**



# TYPES SN54HC673, SN54HC674, SN74HC673, SN74HC674

## 16-BIT SHIFT REGISTERS

### SN54HC674, SN74HC674

The 'HC674 is a 16-bit parallel-in, serial-out shift register. A three-state input/output (SER/Q15) port provides access for entering serial data or reading the shift-register word in a recirculating loop.

The device has four basic modes of operation:

- 1) Hold (do nothing)
- 2) Write (serially via input/output)
- 3) Read (serially)
- 4) Load (parallel via data inputs)

Low-to-high-level changes at the chip select input should be made only when the clock input is low to prevent false clocking.

The SN54HC674 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC674 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

'HC673  
FUNCTION TABLE

INPUTS					SER/ Q15	SHIFT REGISTER FUNCTIONS				STORAGE REGISTER FUNCTIONS	
CS	R/W	SH CLK	STRCLR	MODE/ STRCLK		SHIFT	READ FROM SERIAL OUTPUT	WRITE INTO SERIAL INPUT	PARALLEL LOAD	CLEAR	LOAD
H	X	X	X	X	Z	NO	NO	NO	NO		NO
X	X	X	L	X						YES	
L	L	↓	X	X	Z	YES	NO	YES	NO		
L	H	X	X	X	Q15		YES	NO			NO
L	H	↓	X	L	Q14n	YES	YES	NO	NO		NO
L	H	↓	L	H	L	NO	YES		YES	YES	NO
L	H	↓	H	H	Y15n	NO	YES		YES	NO	NO
L	L	X	H	↑	Z		NO		NO	NO	YES

'HC674 FUNCTION TABLE

INPUTS				SER/ Q15	OPERATION
CS	R/W	MODE	CLK		
H	X	X	X	Z	Do nothing
L	L	X	↓	Z	Shift and write (serial load)
L	H	L	↓	Q14n	Shift and read
L	H	H	↓	P15	Parallel load

H = high level (steady state)

L = low level (steady state)

↑ = transition from low to high level

↓ = transition from high to low level

X = irrelevant (any input including transitions)

Z = high impedance, input mode

Q14n = content of 14th bit of the shift register before the most recent ↓ transition of the clock

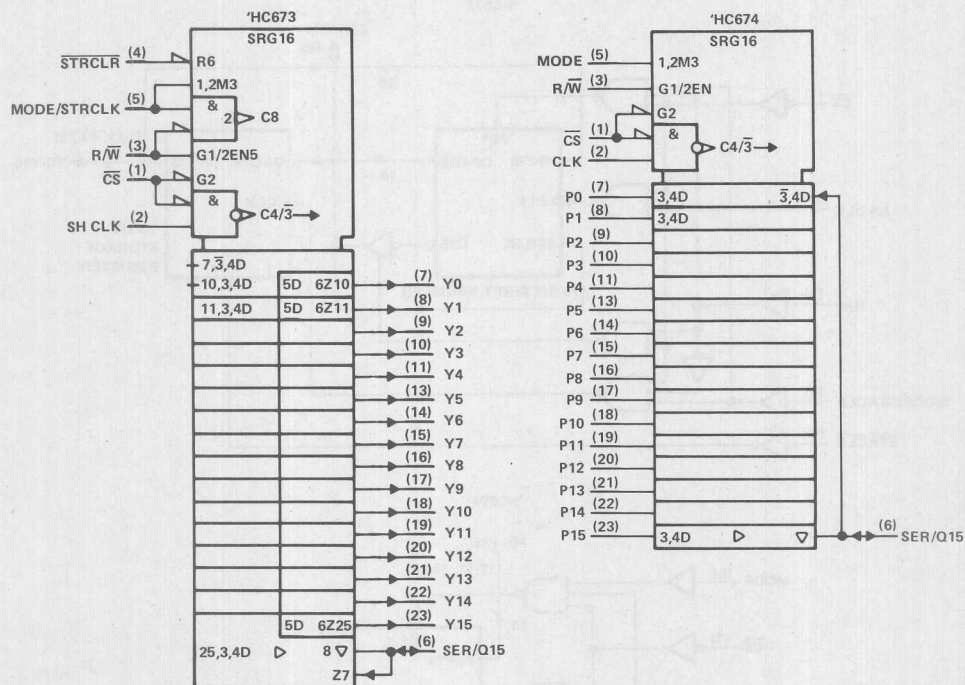
Q15 = present content of 15th bit of the shift register

Y15n = content of the 15th bit of the storage register before the most recent ↓ transition of the clock

P15 = level of input P15

# TYPES SN54HC673, SN54HC674, SN74HC673, SN74HC674 16-BIT SHIFT REGISTERS

## logic symbols



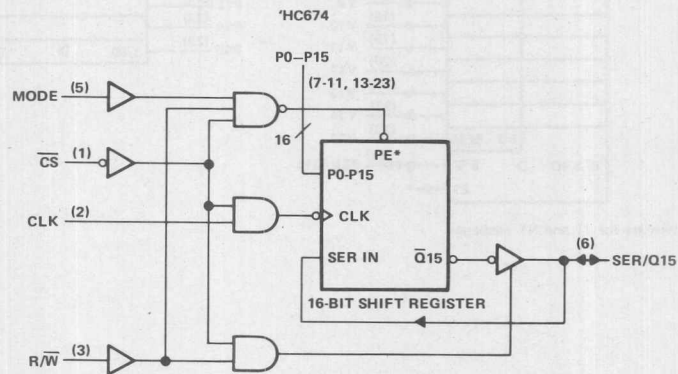
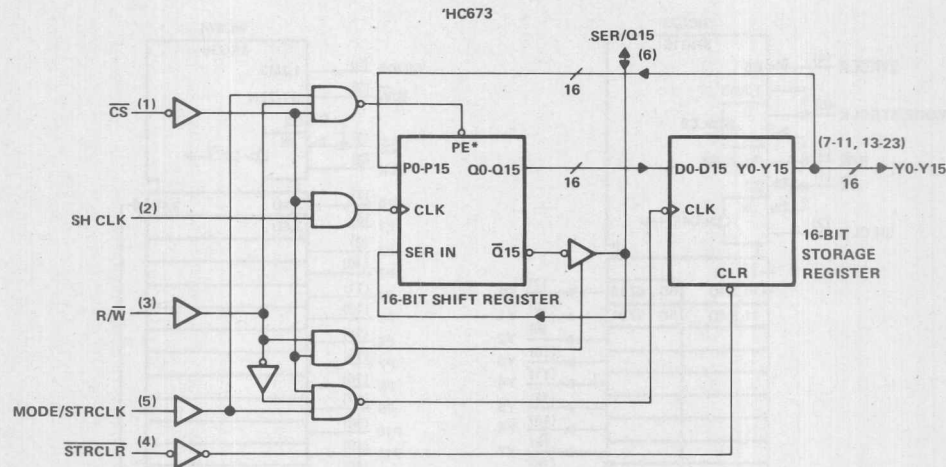
Pin numbers shown are for JT and NT packages.

4

ADVANCE INFORMATION

# **TYPES SN54HC673, SN54HC674, SN74HC673, SN74HC674** **16-BIT SHIFT REGISTERS**

functional block diagrams (positive logic)



\*When PE is active, data is synchronously parallel loaded into the shift registers from the 16 P inputs and no shifting takes place.

Pin numbers shown are for JT and NT packages.

**maximum ratings recommended operating conditions, and electrical characteristics**

See Table III, page 2-8.

4

ADVANCE INFORMATION



**TYPES SN54HC673, SN54HC674, SN74HC673, SN74HC674**  
**16-BIT SHIFT REGISTERS**

**'HC673 timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC673		SN74HC673		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5	0	3.3	0	4	MHz
		4.5 V	0	25	0	17	0	20	
		6 V	0	29	0	19	0	24	
t <sub>w</sub>	Pulse duration, SH CLK or STRCLK high or low	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
t <sub>su</sub>	Setup time before SH CLK↓	SER/Q15, Y0 thru Y15	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	17	26		21		
	MODE, R/W, $\overline{CS}$	2 V	175		265		220		ns
		4.5 V	35		53		44		
		6 V	30		45		37		
t <sub>h</sub>	Hold time, SER/Q15, Y0 thru Y15, MODE, R/W, $\overline{CS}$	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

**'HC674 timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC674		SN74HC674		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	5	0	3.3	0	4	MHz
		4.5 V	0	25	0	17	0	20	
		6 V	0	29	0	19	0	24	
t <sub>w</sub>	Pulse duration, CLK high or low	2 V	100		150		125		ns
		4.5 V	20		30		25		
		6 V	17		26		21		
t <sub>su</sub>	Setup time before CLK↓	SER/Q15, P0 thru P15	2 V	100	150		125		ns
			4.5 V	20	30		25		
			6 V	17	26		21		
	MODE, R/W, $\overline{CS}$	2 V	175		265		220		ns
		4.5 V	35		53		44		
		6 V	30		45		37		
t <sub>h</sub>	Hold time, SER/Q15, P0 thru P15, MODE, R/W, $\overline{CS}$	2 V	0		0		0		ns
		4.5 V	0		0		0		
		6 V	0		0		0		

**4**

**ADVANCE INFORMATION**

# **TYPES SN54HC673, SN54HC674, SN74HC673, SN74HC674** **16-BIT SHIFT REGISTERS**

'HC673 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC673		SN74HC673		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$			2 V	5	7		3.3		4		MHz
			4.5 V	25	28		17		20		
			6 V	29	32		19		24		
$t_{pd}$	MODE/STRCLK	Y	2 V		66						ns
			4.5 V		23						
			6 V		20						
$t_{pd}$	$\overline{\text{STRCLR}}$	Y	2 V		57						ns
			4.5 V		19						
			6 V		16						
$t_{pd}$	SH CLK	SER/Q15	2 V		72						ns
			4.5 V		24						
			6 V		20						
$t_{en}$	$\overline{\text{CS}}, \text{R}/\overline{\text{W}}$	SER/Q15	2 V		66						ns
			4.5 V		23						
			6 V		20						
$t_{dis}$	$\overline{\text{CS}}, \text{R}/\overline{\text{W}}$	SER/Q15	2 V		66						ns
			4.5 V		23						
			6 V		20						

4

ADVANCE INFORMATION

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	150 pF typ
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'HC674 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC674		SN74HC674		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{max}$			2 V	5	7		3.3		4		MHz
			4.5 V	25	28		17		20		
			6 V	29	32		19		24		
$t_{pd}$	CLK	SER/Q15	2 V		72						ns
			4.5 V		24						
			6 V		20						
$t_{en}$	$\overline{\text{CS}}, \text{R}/\overline{\text{W}}$	SER/Q15	2 V		70						ns
			4.5 V		23						
			6 V		20						
$t_{dis}$	$\overline{\text{CS}}, \text{R}/\overline{\text{W}}$	SER/Q15	2 V		70						ns
			4.5 V		23						
			6 V		20						

$C_{pd}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	150 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC677, SN54HC678, SN74HC677, SN74HC678 16-BIT ADDRESS COMPARATORS

D2833, MARCH 1984

- 'HC677 is a 16-Bit Address Comparator with Enable
- 'HC678 is a 16-Bit Address Comparator with Latch
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

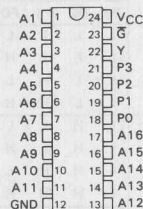
### description

The 'HC677 and 'HC678 address comparators simplify addressing of memory boards and/or other peripheral devices. The four P inputs are normally hard wired with a preprogrammed address. An internal decoder determines what input information applied to the 16 A inputs must be low or high to cause a low state at the output (Y). For example, a positive-logic bit combination of 0111 (decimal 7) at the P input determines that inputs A1 through A7 must be low and that inputs A8 through A16 must be high to cause the output to go low. Equality of the address applied at the A inputs to the preprogrammed address is indicated by the output being low.

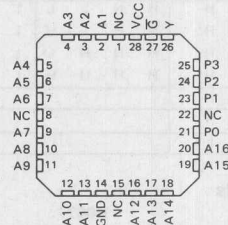
The 'HC677 features an enable input ( $\bar{G}$ ). When  $\bar{G}$  is low, the device is enabled. When  $\bar{G}$  is high, the device is disabled and the output is high regardless of the A and P inputs. The 'HC678 features a transparent latch and a latch enable input (C). When C is high, the device is in the transparent mode. When C is low, the previous logic state of Y is latched.

The SN54HC677 and SN54HC678 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN54HC677 and SN74HC678 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

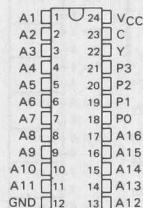
SN54HC677 ... JT PACKAGE  
SN74HC677 ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



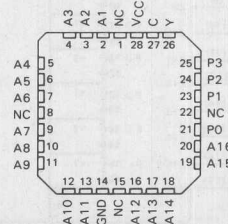
SN54HC677 ... FH OR FK PACKAGE  
(TOP VIEW)



SN54HC678 ... JT PACKAGE  
SN74HC678 ... JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC678 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

ADVANCE INFORMATION  
This document contains information on a new product. Specifications are subject to change without notice.

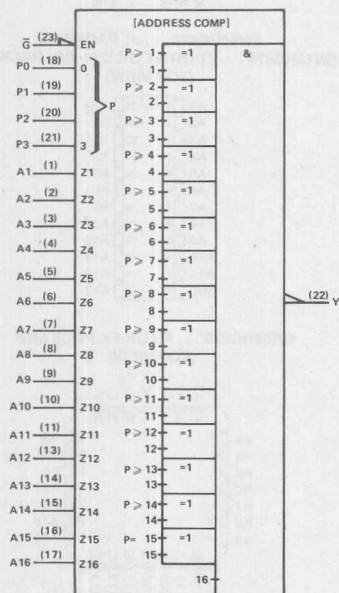
TEXAS  
INSTRUMENTS

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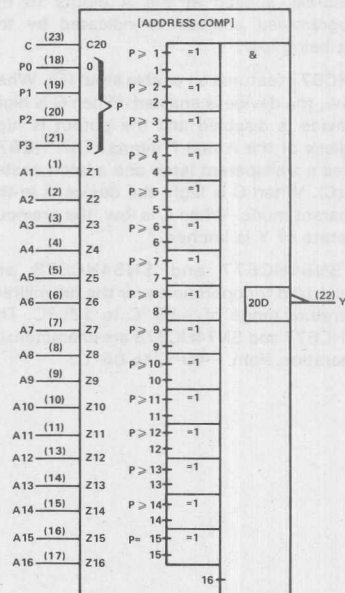
[illegible]

**logic symbols**

## 'HC677



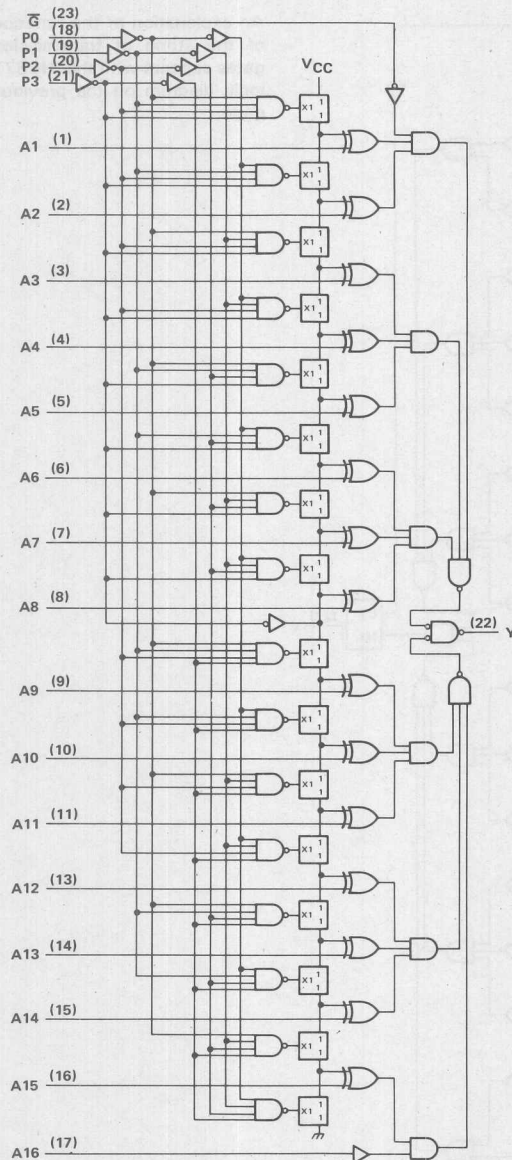
## [ADDRESS COMP]



Pin numbers shown are for JT and NT packages.

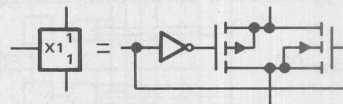
# **TYPES SN54HC677, SN74HC677** **16-BIT ADDRESS COMPARATORS**

'HC677 logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

In order to understand the implementation of this device, it is essential that the function of the vertical string of transmission gates be understood. A schematic of one of these gates is shown below. If the input to the transmission gate labeled "X1" is high, then the transmission path between the two ports labeled "1" is on. If the "X1" input is low, then the transmission path between the two ports labeled "1" is off. Only one of the 16 transmission gates can be off while the device is operating; which one is off is determined by inputs P0 through P3. The lines going from the string of transmission gates to the exclusive-OR gates located above the transmission gate that is off will be high. The lines going to the exclusive-OR gates located below that transmission gate will be low.

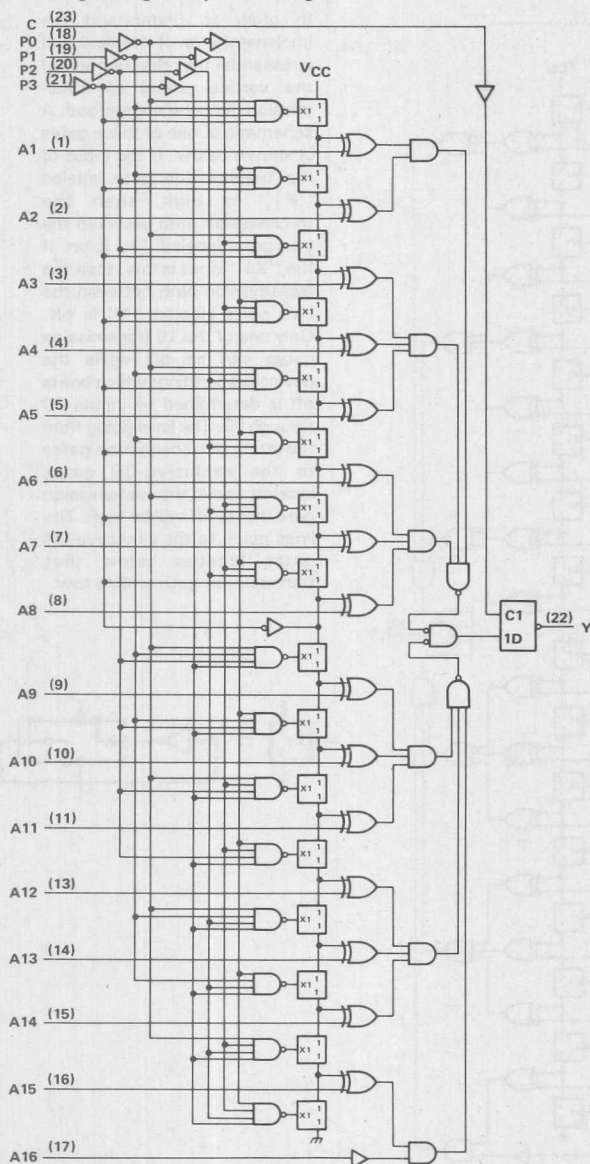


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ADVANCE INFORMATION

# **TYPES SN54HC678, SN74HC678** **16-BIT ADDRESS COMPARATORS**

'HC678 logic diagram (positive logic)



An explanation of the function of the string of transmission gates appears with the 'HC677 logic diagram on the previous page.

4

ADVANCE INFORMATION

Pin numbers shown are for JT and NT packages.



# TYPES SN54HC677, SN54HC678, SN74HC677, SN74HC678 16-BIT ADDRESS COMPARATORS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

'HC677 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC677		SN74HC677		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	Any P	Y	2 V		160						ns
			4.5 V		32						
			6 V		27						
t <sub>pd</sub>	Any A	Y	2 V		90						ns
			4.5 V		18						
			6 V		15						
t <sub>pd</sub>	$\bar{G}$	Y	2 V		70						ns
			4.5 V		14						
			6 V		12						
t <sub>t</sub>		Y	2 V		38						ns
			4.5 V		8						
			6 V		6						

'HC678 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC678		SN74HC678		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	Any P	Y	2 V		165						ns
			4.5 V		33						
			6 V		28						
t <sub>pd</sub>	Any A	Y	2 V		105						ns
			4.5 V		21						
			6 V		18						
t <sub>pd</sub>	C	Y	2 V		75						ns
			4.5 V		15						
			6 V		13						
t <sub>t</sub>		Y	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

## TYPES SN54HC677, SN54HC678, SN74HC677, SN74HC678 16-BIT ADDRESS COMPARATORS

### TYPICAL APPLICATION INFORMATION

The 'HC677 and 'HC678 can be wired to recognize any one of  $2^{16}$  addresses. The number of "lows" in the address determines the input pattern for the P inputs. Then those system address lines that are low in the address to be recognized are connected to the lowest numbered A inputs of the address comparator and the system address lines that are high are connected to the highest numbered A inputs.

For example, assume the comparator is to enable a device when the 16-bit system address is:

A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
H	H	L	L	H	H	L	L	H	H	L	L	H	H	H	H

Since the address contains 6 lows and 10 highs, the following connections are made:

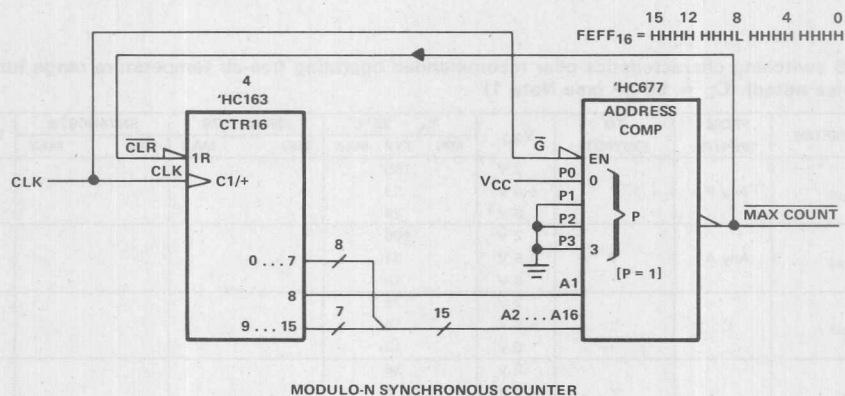
P3 to 0 V, P2 to VCC, P1 to VCC, and P0 to 0 V.

System address lines A13, A12, A9, A8, A5, and A4 to comparator inputs A1 through A6 in any convenient order.

The remaining ten system address lines to comparator inputs A7 through A16 in any convenient order.

The output provides an active-low enabling signal.

The following circuit is a modulo-N synchronous counter. The 'HC163 is connected to provide a low-level clear signal when  $N = \text{FEFF}_{16}$ .



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ADVANCE INFORMATION

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC679, SN54HC680, SN74HC679, SN74HC680 12-BIT ADDRESS COMPARATORS

D2833, MARCH 1984

- 'HC679 is a 12-Bit Address Comparator With Enable
- 'HC680 is a 12-Bit Address Comparator With Latch
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

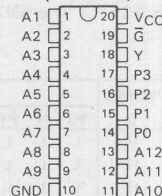
### description

The 'HC679 and 'HC680 address comparators simplify addressing of memory boards and/or other peripheral devices. The four P inputs are normally hard wired with a preprogrammed address. An internal decoder determines what input information applied to the 12 A inputs must be low or high to cause a low state at the output (Y). For example, a positive-logic bit combination of 0111 (decimal 7) at the P input determines that inputs A1 through A7 must be low and that inputs A8 through A12 must be high to cause the output to go low. Equality of the address applied at the A inputs to the preprogrammed address is indicated by the output being low.

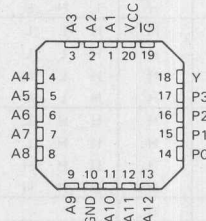
The 'HC679 features an enable input ( $\bar{G}$ ). When  $\bar{G}$  is low, the device is enabled. When  $\bar{G}$  is high, the device is disabled and the output is high regardless of the A and P inputs. The 'HC680 features a transparent latch and a latch enable input (C). When C is high, the device is in the transparent mode. When C is low, the previous logical state of Y is latched.

The 'HC679 and 'HC680 are functionally unilaterally interchangeable with the ALSTTL counterparts, 'ALS679 and 'ALS680, in all cases of normal use as 12-bit address comparators. They differ in two respects. First, they may be programmed to recognize all A inputs low either by connecting all P inputs high (1111 = decimal 15), or by combination HHL (1100 = 12), the latter option not being valid for the ALSTTL parts. Second, the combinations HHLH and HHHL (1101 = 13 and 1110 = 14) cannot be used (but are not needed) in address-comparator applications. These two combinations cause the outputs to be disabled (high).

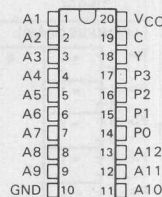
SN54HC679... J PACKAGE  
SN74HC679... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



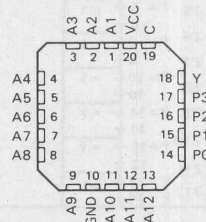
SN54HC679... FH OR FK PACKAGE  
(TOP VIEW)



SN54HC680... J PACKAGE  
SN74HC680... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC680... FH OR FK PACKAGE  
(TOP VIEW)



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ADVANCE INFORMATION

### ADVANCE INFORMATION

This document contains information on a new product. Specifications are subject to change without notice.

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# TYPES SN54HC679, SN54HC680, SN74HC679, SN74HC680 12-BIT ADDRESS COMPARATORS

## description (continued)

The SN54HC679 and SN54HC680 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC679 and SN74HC680 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

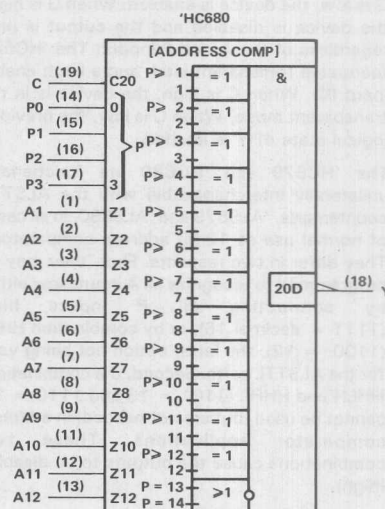
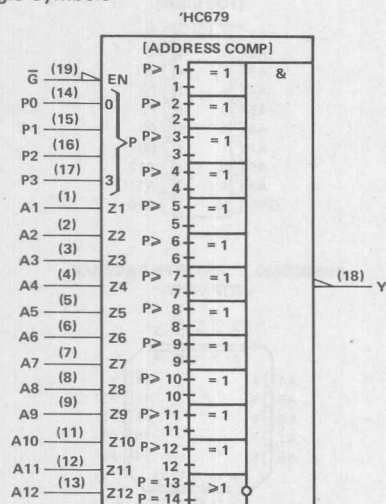
FUNCTION TABLE

'HC679	'HC680	INPUTS COMMON TO 'HC679 AND 'HC680																OUTPUT
$\bar{G}$	C	P3	P2	P1	P0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	Y
L	H	L	L	L	L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	H	L	L	L	H	L	H	H	H	H	H	H	H	H	H	H	H	L
L	H	L	L	H	L	L	L	H	H	H	H	H	H	H	H	H	H	L
L	H	L	L	H	H	L	L	L	H	H	H	H	H	H	H	H	H	L
L	H	L	H	L	L	L	L	L	L	H	H	H	H	H	H	H	H	L
L	H	L	H	L	H	L	L	L	L	L	L	H	H	H	H	H	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	H	H	H	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	H	H	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
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L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
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L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
L	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

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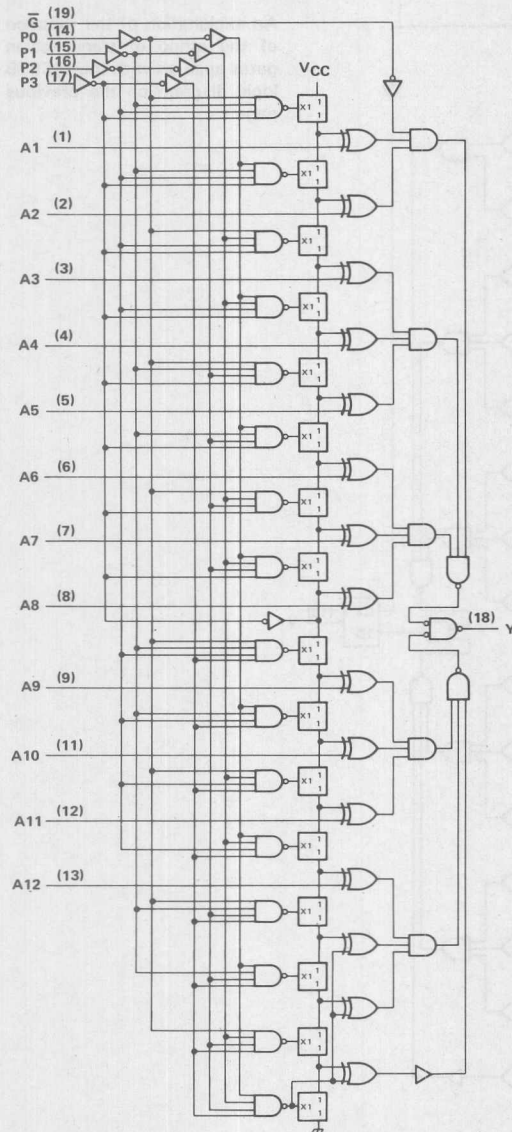
ADVANCE INFORMATION

## logic symbols

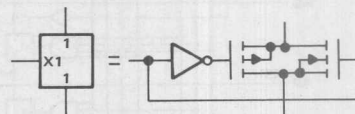


# TYPES SN54HC679, SN74HC679 12-BIT ADDRESS COMPARATORS

'HC679 logic diagram (positive logic)



In order to understand the implementation of this device, it is essential that the function of the vertical string of transmission gates be understood. A schematic of one of these gates is shown below. If the input to the transmission gate labeled "X1" is high, then the transmission path between the two ports labeled "1" is on. If the "X1" input is low, then the transmission path between the two ports labeled "1" is off. Only one of the 16 transmission gates can be off while the device is operating; which one is off is determined by inputs P0 through P3. The lines going from the string of transmission gates to the Exclusive-OR gates located above the transmission gate that is off will be high. The lines going to the Exclusive-OR gates located below that transmission gate will be low.

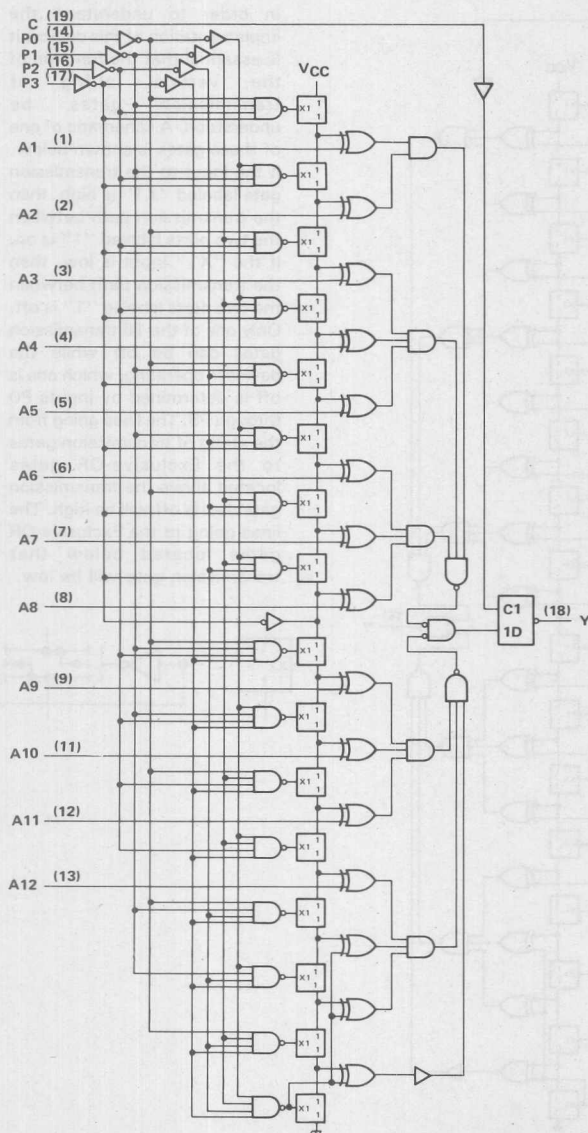


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ADVANCE INFORMATION

**TYPES SN54HC680, SN74HC680**  
**12-BIT ADDRESS COMPARATORS**

'HC680 logic diagram (positive logic)



An explanation of the function of the string of transmission gates appears with the 'HC679 logic diagram on the previous page.

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**ADVANCE INFORMATION**



# TYPES SN54HC679, SN54HC680, SN74HC679, SN74HC680 12-BIT ADDRESS COMPARATORS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

**'HC679 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC679		SN74HC679		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any P	Y	2 V		160						ns
			4.5 V		32						
			6 V		27						
$t_{pd}$	Any A	Y	2 V		90						ns
			4.5 V		18						
			6 V		15						
$t_{pd}$	$\overline{G}$	Y	2 V		70						ns
			4.5 V		14						
			6 V		12						
$t_t$		Y	2 V		38						ns
			4.5 V		8						
			6 V		6						

**'HC680 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC680		SN74HC680		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	Any P	Y	2 V		165						ns
			4.5 V		33						
			6 V		28						
$t_{pd}$	Any A	Y	2 V		105						ns
			4.5 V		21						
			6 V		18						
$t_{pd}$	C	Y	2 V		75						ns
			4.5 V		15						
			6 V		13						
$t_t$		Y	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

# **TYPES SN54HC679, SN54HC680, SN74HC679, SN74HC680** **12-BIT ADDRESS COMPARATORS**

## **TYPICAL APPLICATION INFORMATION**

The 'HC679 and 'HC680 can be wired to recognize any one of  $2^{12}$  addresses. The number of "lows" in the address determines the input pattern for the P inputs. Then those system address lines that are low in the address to be recognized are connected to the lowest numbered A inputs of the address comparator and the system address lines that are high are connected to the highest numbered A inputs.

For example, assume the comparator is to enable a device when the 12-bit system address is:

A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
H	H	L	L	H	H	L	L	H	H	H	H

Since the address contains 4 lows and 8 highs, the following connections are made.

P3 to 0 V, P2 to  $V_{CC}$ , P1 to 0 V, and P0 to 0 V.

System address lines A9, A8, A5, and A4 to comparator inputs A1 through A4 in any convenient order.

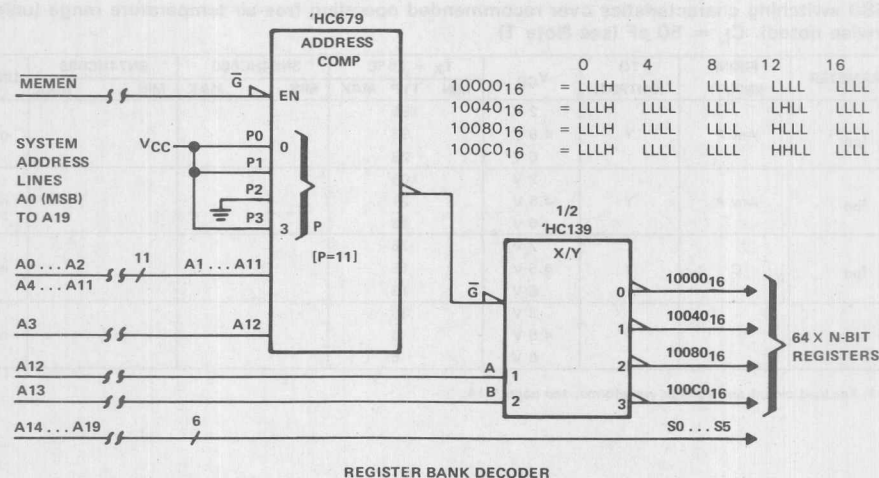
The remaining eight system address lines to comparator inputs A5 through A12 in any convenient order.

The output provides an active-low enabling signal.

The following circuit is a register bank decoder that examines the 14 most significant bits (A0 through A13) of a 20-bit address to select banks corresponding to the hex addresses 10000, 10040, 10080, and 100C0.

## **4**

## **ADVANCE INFORMATION**



## D2804. MARCH 1984

- |     |    |    |                 |
|-----|----|----|-----------------|
| P>Q | 1  | 20 | V <sub>CC</sub> |
| P0  | 2  | 19 | P=Q             |
| Q0  | 3  | 18 | Q7              |
| P1  | 4  | 17 | P7              |
| Q1  | 5  | 16 | Q6              |
| P2  | 6  | 15 | P6              |
| Q2  | 7  | 14 | Q5              |
| P3  | 8  | 13 | P5              |
| Q3  | 9  | 12 | Q4              |
| GND | 10 | 11 | P4              |

P > Q	1	24	V <sub>CC</sub>
$\overline{G_1}$	2	23	$\overline{G_2}$
P0	3	22	P = Q
Q0	4	21	Q7
P1	5	20	P7
Q1	6	19	NC
NC	7	18	Q6
P2	8	17	P6
Q2	9	16	Q5
P3	10	15	P5
Q3	11	14	Q4
GND	12	13	P4

**TYPES SN54HC682, SN54HC684, SN54HC686  
SN74HC682, SN74HC684, SN74HC686  
8-BIT MAGNITUDE COMPARATORS**

FUNCTION TABLE

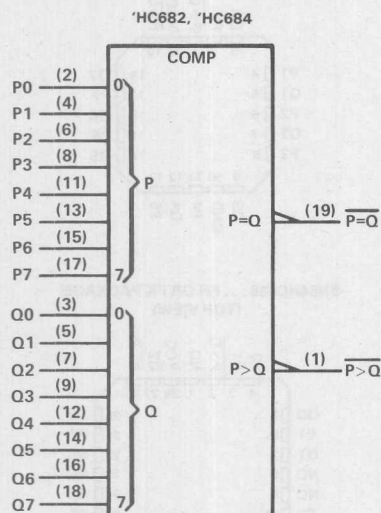
DATA P, Q	INPUTS ENABLES		OUTPUTS	
	$\bar{G}1$	$\bar{G}2$	$P=\bar{Q}$	$P>\bar{Q}$
P=Q	L	X	L	H
P>Q	X	L	H	L
P<Q	X	X	H	H
P=Q	H	X	H	H
P>Q	X	H	H	H
X	H	H	H	H

- NOTES: 1. The last 3 lines of the function table apply only to the device having enable inputs, i.e., 'HC686.  
2. The  $P<\bar{Q}$  function can be generated by applying the  $P=\bar{Q}$  and  $P>\bar{Q}$  outputs to a 2-input NAND gate.

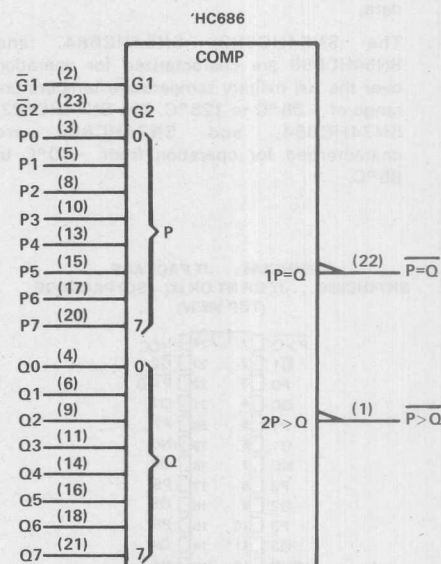
logic symbols

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ADVANCE INFORMATION



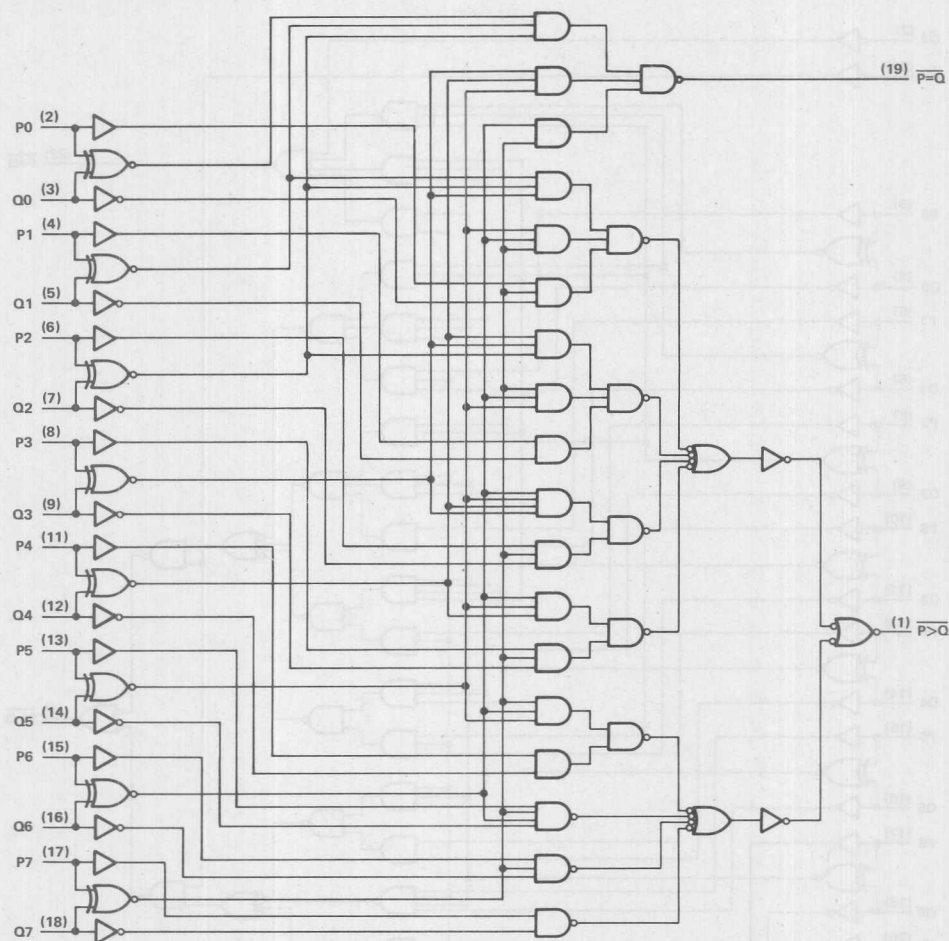
'HC682 has 20-kΩ pullup resistors on the Q inputs



'HC686 pin numbers shown are for JT and NT packages.

**TYPES SN54HC682, SN54HC684  
SN74HC682, SN74HC684  
8-BIT MAGNITUDE COMPARATORS**

'HC682, 'HC684 logic diagram (positive logic)

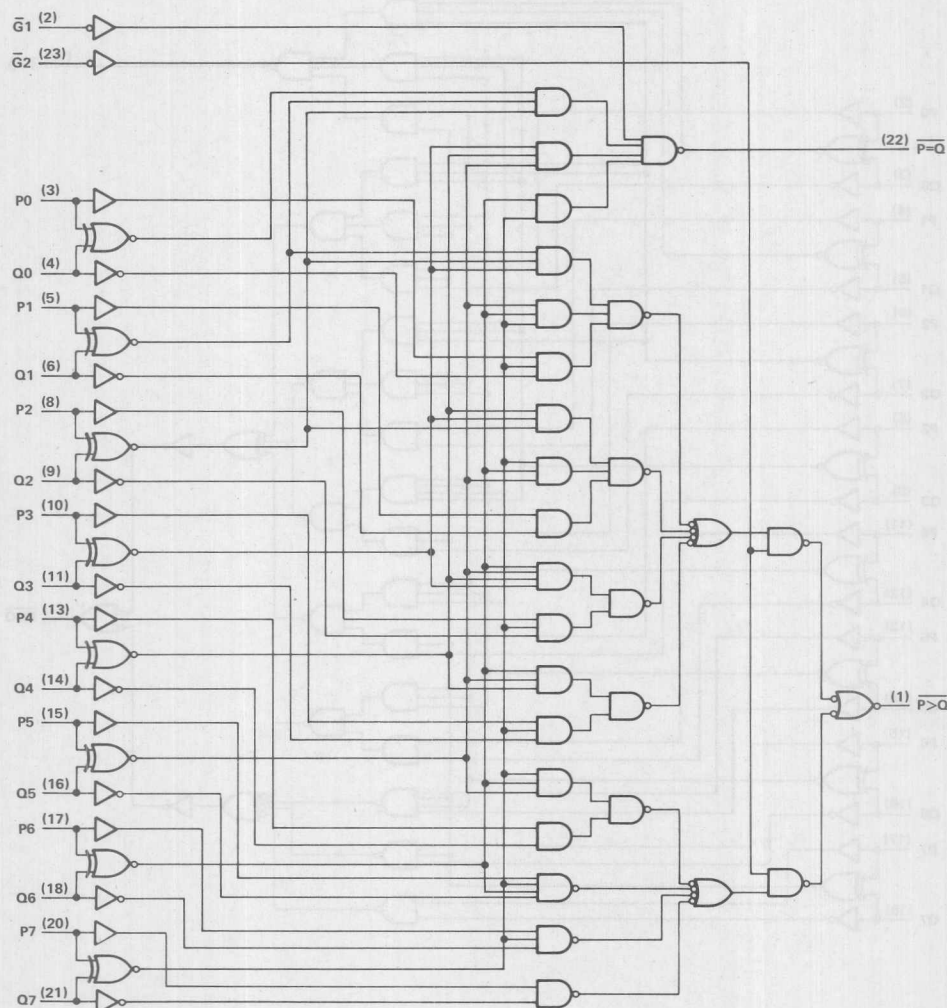


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ADVANCE INFORMATION

**TYPES SN54HC686, SN74HC686**  
**8-BIT MAGNITUDE COMPARATORS**

'HC686 logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

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ADVANCE INFORMATION



**TYPES SN54HC682, SN54HC684, SN54HC686  
SN74HC682, SN74HC684, SN74HC686  
8-BIT MAGNITUDE COMPARATORS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

'HC682, 'HC684 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC682 SN54HC684		SN74HC682 SN74HC684		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	P or Q	Any	2 V		130	210		313		265	ns
			4.5 V		26	42		63		53	
			6 V		22	36		53		45	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

'HC686 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC686		SN74HC686		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	P or Q	Any	2 V			80					ns
			4.5 V			16					
			6 V			14					
$t_{pd}$	$\overline{G}1$ or $\overline{G}2$	Any	2 V			55					ns
			4.5 V			11					
			6 V			9					
$t_t$		Any	2 V			38					ns
			4.5 V			8					
			6 V			6					

NOTE 1: For load circuit and voltage waveforms see page 1-14.

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ADVANCE INFORMATION



# **HIGH-SPEED CMOS LOGIC**

# **TYPES SN54HC688, SN74HC688 8-BIT IDENTITY COMPARATORS**

D2684, DECEMBER 1982—REVISED MARCH 1984

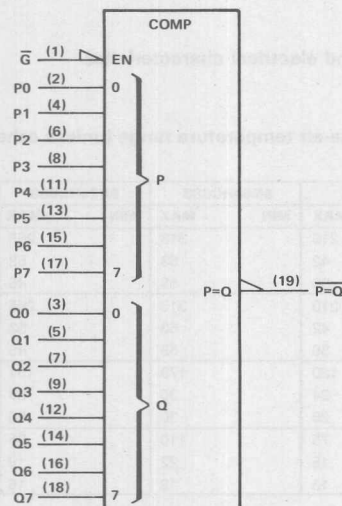
- Compares Two Eight-Bit Words
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## **description**

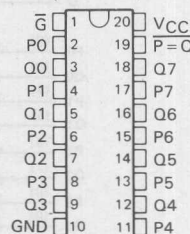
These identity comparators perform comparisons of two eight-bit binary or BCD words. An enable input ( $\bar{G}$ ) may be used to force the output to the high level.

The SN54HC688 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC688 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

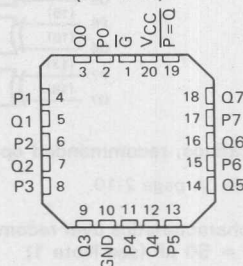
## **logic symbol**



SN54HC688...J PACKAGE  
SN74HC688...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC688...FH OR FK PACKAGE  
(TOP VIEW)



**FUNCTION TABLE**

INPUTS		OUTPUT
DATA P, Q	ENABLE $\bar{G}$	
P = Q	L	L
P > Q	X	H
P < Q	X	H
X	H	H

4

ADVANCE INFORMATION

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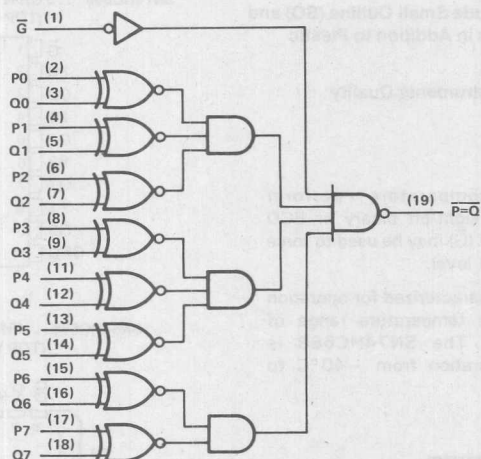
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INSTRUMENTS**

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# **TYPES SN54HC688, SN74HC688** **8-BIT IDENTITY COMPARATORS**

logic diagram (positive logic)



4

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HC688		SN74HC688		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	P	$\overline{P=Q}$	2 V		113	210		313		265	ns
			4.5 V		30	42		63		53	
			6 V		24	36		53		45	
$t_{pd}$	Q	$\overline{P=Q}$	2 V		113	210		313		265	ns
			4.5 V		30	42		63		53	
			6 V		24	36		53		45	
$t_{pd}$	$\overline{G}$	$\overline{P=Q}$	2 V		66	120		179		151	ns
			4.5 V		16	24		36		30	
			6 V		14	20		30		26	
$t_t$		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

ADVANCE INFORMATION

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC690 THRU SN54HC693, SN74HC690 THRU SN74HC693 SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS AND MULTIPLEXED 3-STATE OUTPUTS

D2804, MARCH 1984

- 4-Bit Counters/Registers
- 3-State Outputs Drive Bus Lines Directly
- 'HC690 . . . Decade Counter, Direct Clear
- 'HC691 . . . Binary Counter, Direct Clear
- 'HC692 . . . Decade Counter, Synchronous Clear
- 'HC693 . . . Binary Counter, Synchronous Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

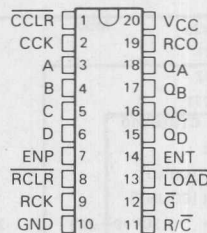
### description

These devices incorporate synchronous up/down counters, four-bit D-type registers, and quadruple two-line to one-line multiplexers with three-state outputs in a single 20-pin package. The up/down counters are programmable from the data inputs and feature enable P (ENP) and enable T (ENT) inputs and a ripple-carry output (RCO) for easy expansion. The register/counter select input (R/C) selects the counter when low and the register when high for the three-state outputs,  $Q_A$ ,  $Q_B$ ,  $Q_C$ , and  $Q_D$ .

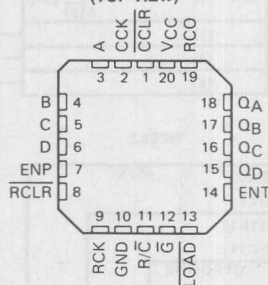
Individual clock and clear inputs are provided for both the counter and the register. Both clock inputs are positive-edge triggered. The clear line is active low and is asynchronous on the 'HC690 and 'HC691, synchronous on the 'HC692 and 'HC693.

The SN54HC690 through SN54HC693 are characterized for operation over the full military range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC690 through SN74HC693 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC690 THRU SN54HC693 . . . J PACKAGE  
SN74HC690 THRU SN74HC693 . . . J OR N OR D (= SO) PACKAGE



SN54HC690 THRU SN54HC693 . . . FH OR FK PACKAGE  
(TOP VIEW)



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subject to change without notice.

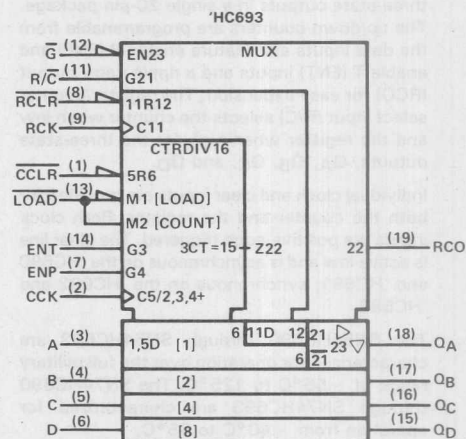
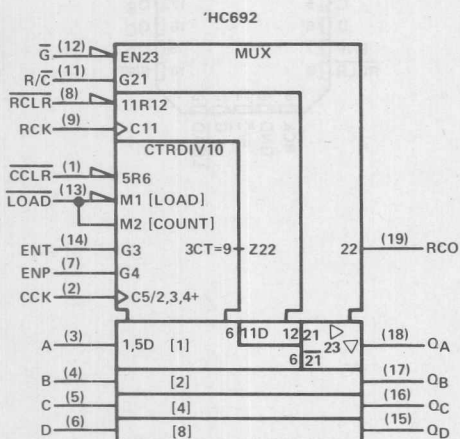
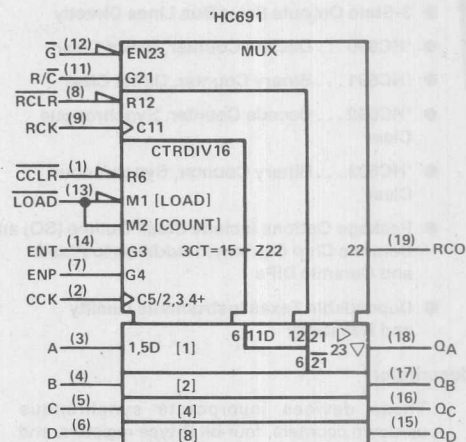
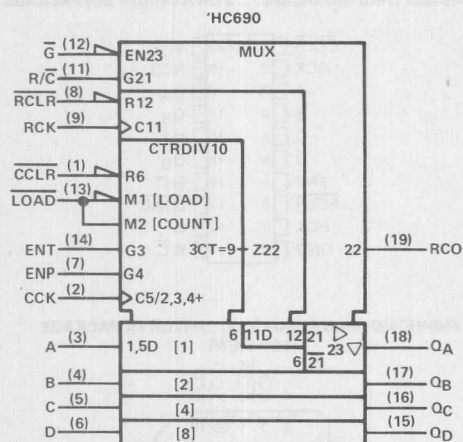
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**TYPES SN54HC690 THRU SN54HC693, SN74HC690 THRU SN74HC693**  
**SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

logic symbols



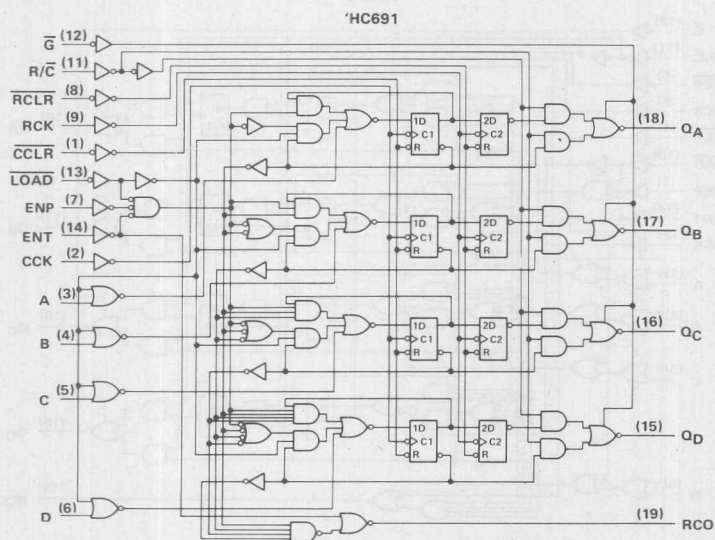
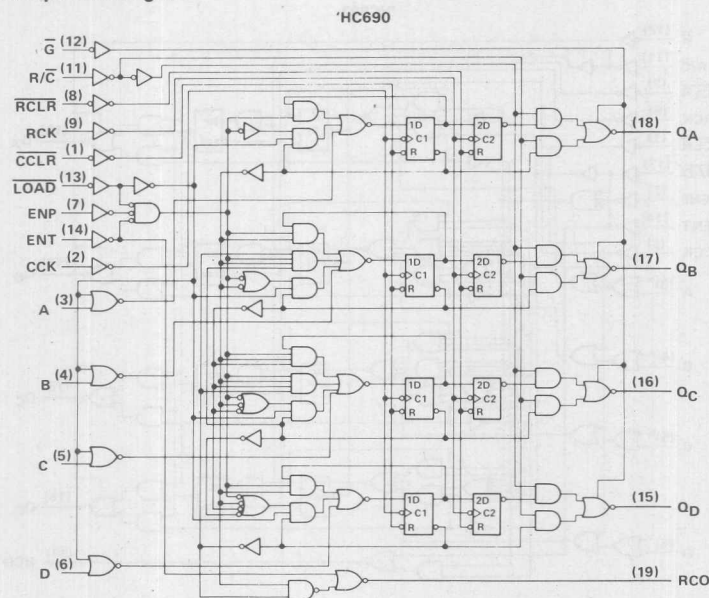
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ADVANCE INFORMATION



**TYPES SN54HC690, SN54HC691, SN74HC690, SN74HC691  
SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS  
AND MULTIPLEXED 3-STATE OUTPUTS**

logic diagrams (positive logic)

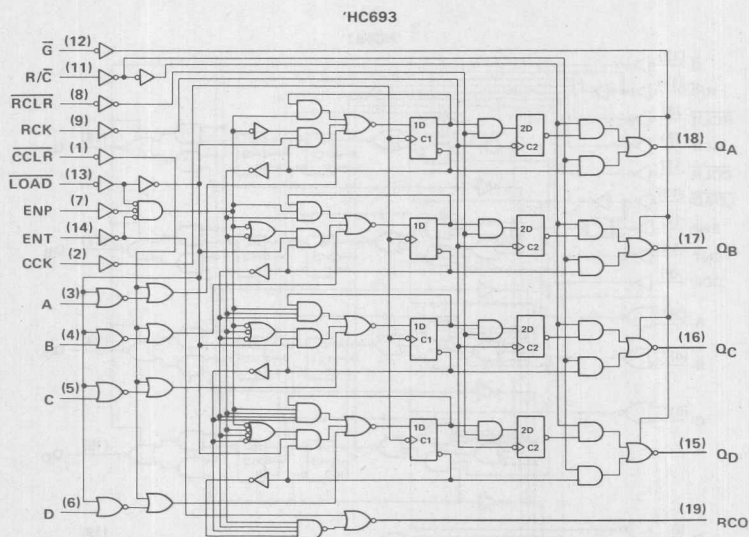
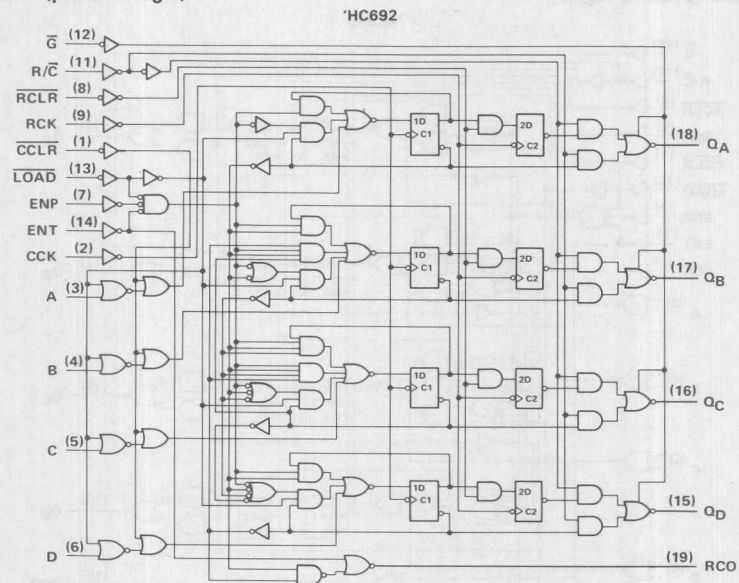


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ADVANCE INFORMATION

**TYPES SN54HC692, SN54HC693, SN74HC692, SN74HC693**  
**SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

logic diagrams (positive logic)



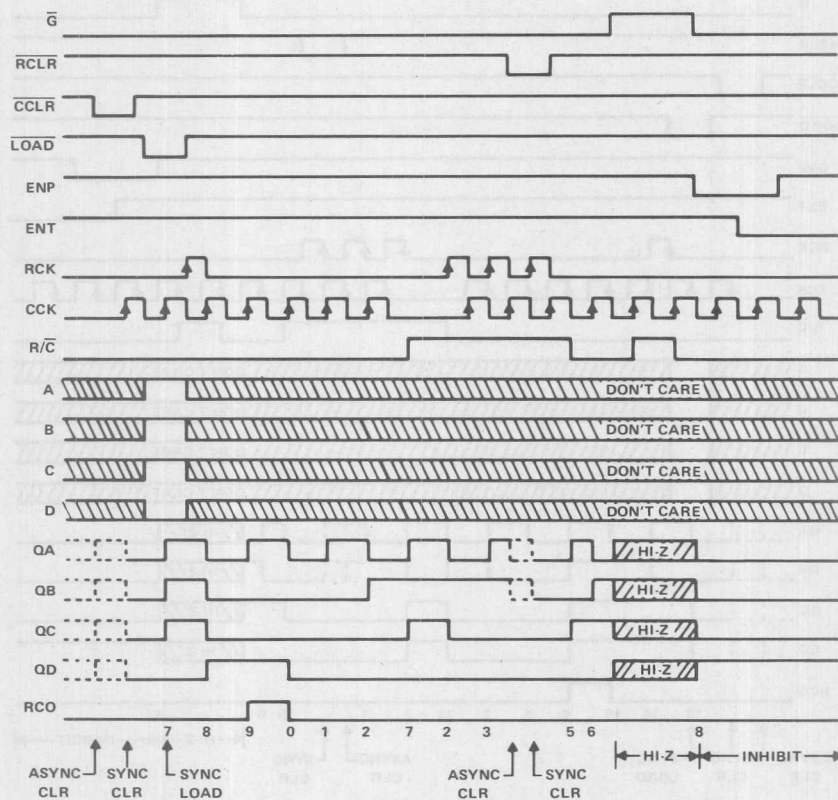
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ADVANCE INFORMATION

**TYPES SN54HC690, SN54HC692, SN74HC690, SN74HC692**  
**SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

**typical operating sequences**

'HC690 DECADE COUNTER, Asynchronous Clear  
 'HC692 DECADE COUNTER, Synchronous Clear

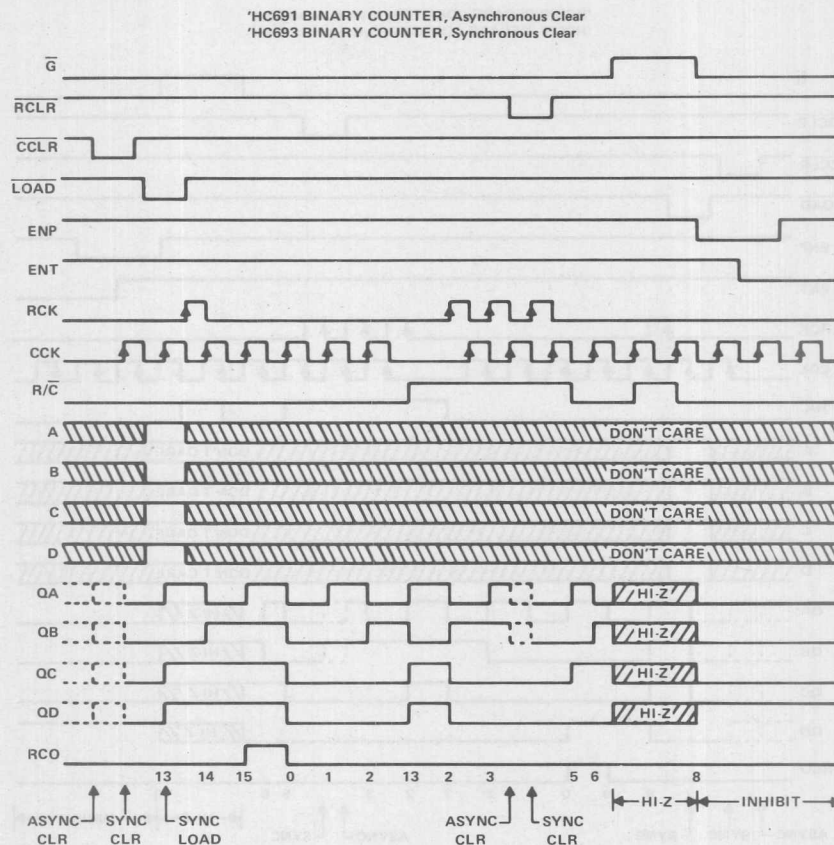


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**ADVANCE INFORMATION**

**TYPES SN54HC691, SN54HC693, SN74HC691, SN74HC693**  
**SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

typical operating sequences



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ADVANCE INFORMATION

**TYPES SN54HC690, SN54HC691, SN74HC690, SN74HC691  
SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS  
AND MULTIPLEXED 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC690 SN54HC691		SN74HC690 SN74HC691		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CCK↑	RCO	2 V		105						ns
			4.5 V		21						
			6 V		18						
t <sub>pd</sub>	ENT	RCO	2 V		50						ns
			4.5 V		10						
			6 V		9						
t <sub>pd</sub>	CLK↑	Q	2 V		85						ns
			4.5 V		17						
			6 V		14						
t <sub>pd</sub>	RCK↑	Q	2 V		75						ns
			4.5 V		15						
			6 V		13						
t <sub>PHL</sub>	$\overline{\text{CCLR}}\downarrow$	Q	2 V		85						ns
			4.5 V		17						
			6 V		14						
t <sub>PHL</sub>	$\overline{\text{CCLR}}\downarrow$	RCO	2 V		115						ns
			4.5 V		23						
			6 V		20						
t <sub>PHL</sub>	$\overline{\text{RCLR}}\downarrow$	Q	2 V		80						ns
			4.5 V		16						
			6 V		14						
t <sub>pd</sub>	R/ $\overline{\text{C}}$	Q	2 V		55						ns
			4.5 V		11						
			6 V		9						
t <sub>en</sub>	$\overline{\text{G}}\downarrow$	Q	2 V		50						ns
			4.5 V		10						
			6 V		9						
t <sub>dis</sub>	$\overline{\text{G}}\uparrow$	Q	2 V		80						ns
			4.5 V		16						
			6 V		14						
t <sub>t</sub>		Any	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

**TYPES SN54HC692, SN54HC693, SN74HC692, SN74HC693**  
**SYNCHRONOUS COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC692 SN54HC693		SN74HC692 SN74HC693		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	CCK↑	RCO	2 V		105						ns
			4.5 V		21						
			6 V		18						
t <sub>pd</sub>	ENT	RCO	2 V		50						ns
			4.5 V		10						
			6 V		9						
t <sub>pd</sub>	CCK↑	Any Q	2 V		85						ns
			4.5 V		17						
			6 V		14						
t <sub>pd</sub>	RCK↑	Any Q	2 V		80						ns
			4.5 V		16						
			6 V		14						
t <sub>pd</sub>	R/ $\overline{C}$	Any Q	2 V		55						ns
			4.5 V		11						
			6 V		9						
t <sub>en</sub>	$\overline{G}$ ↓	Any Q	2 V		50						ns
			4.5 V		10						
			6 V		9						
t <sub>dis</sub>	$\overline{G}$ ↑	Any Q	2 V		80						ns
			4.5 V		16						
			6 V		14						
t <sub>t</sub>		Any	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC696 THRU SN54HC699, SN74HC696 THRU SN74HC699 SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS AND MULTIPLEXED 3-STATE OUTPUTS

D2804, MARCH 1984

- 4-Bit Counters/Registers
- Multiplexed Outputs for Counter or Latched Data
- High-Current 3-State Outputs Drive Bus Lines Directly or up to 15 LSTTL Loads
- 'HC696 . . . Decade Counter, Direct Clear
- 'HC697 . . . Binary Counter, Direct Clear
- 'HC698 . . . Decade Counter, Synchronous Clear
- 'HC699 . . . Binary Counter, Synchronous Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

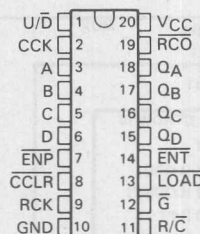
### description

These high-speed CMOS devices incorporate synchronous up/down counters, four-bit D-type registers, and quadruple two-line to one-line multiplexers with three-state outputs in a single 20-pin package. The up/down counters are programmable from the data inputs and feature enable  $\bar{P}$  (ENP) and enable  $\bar{T}$  (ENT) and ripple-carry output (RCO) for easy expansion. The register/counter select input (R/C) selects the counter when low and the register when high for the three-state outputs  $Q_A$ ,  $Q_B$ ,  $Q_C$ , and  $Q_D$ .

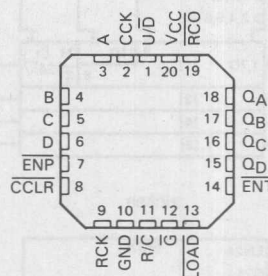
Both the counter clock (CCK) and register clock (RCK) are positive-edge triggered. The counter clear ( $\bar{CCLR}$ ) is active low and asynchronous on the 'HC696 and 'HC697, synchronous on the 'HC698 and 'HC699.

The SN54HC696 through SN54HC699 are characterized for operation over the full military range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC696 through SN74HC699 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC696 THRU SN54HC699 . . . J PACKAGE  
SN74HC696 THRU SN74HC699 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC696 THRU SN54HC699 . . . FH OR FK PACKAGE  
(TOP VIEW)



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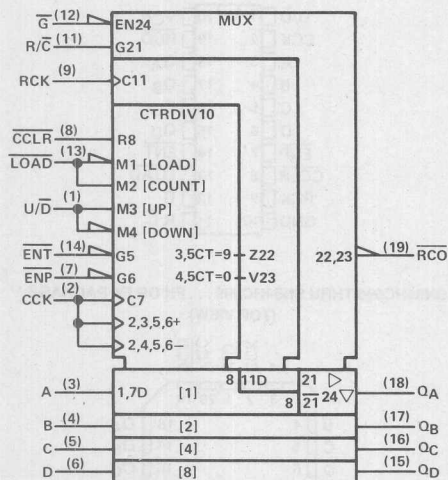
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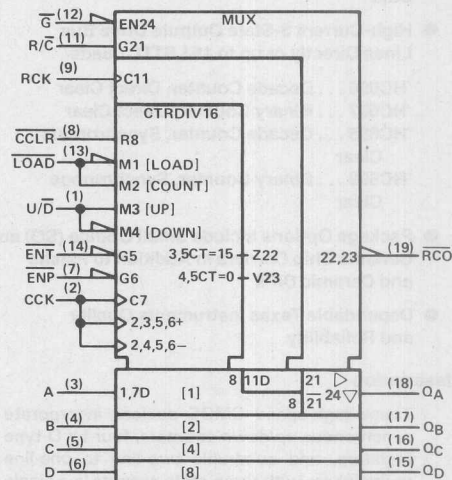
**TYPES SN54HC696 THRU SN54HC699, SN74HC696 THRU SN74HC699**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

**logic symbols**

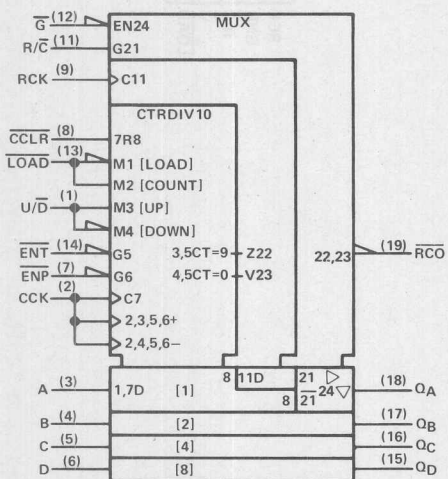
**'HC696**



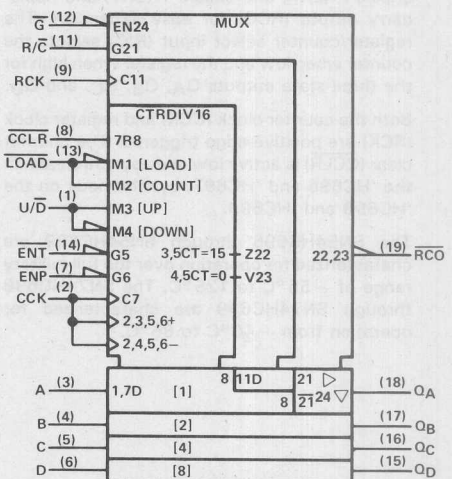
**'HC697**



**'HC698**



**'HC699**

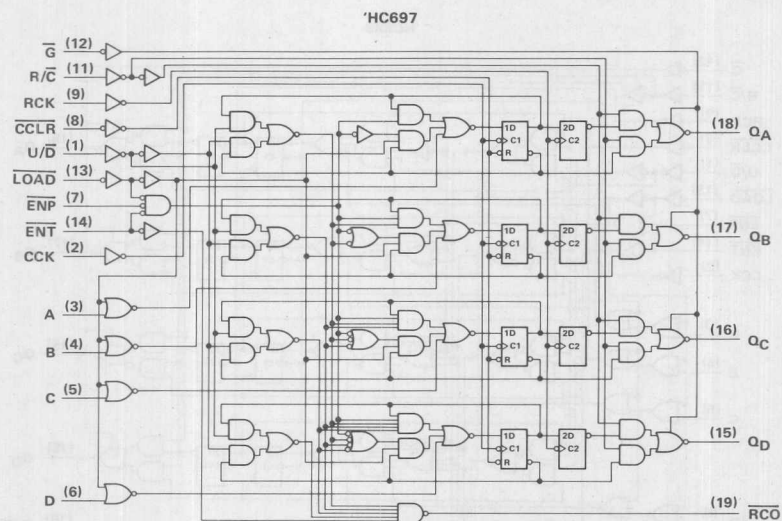
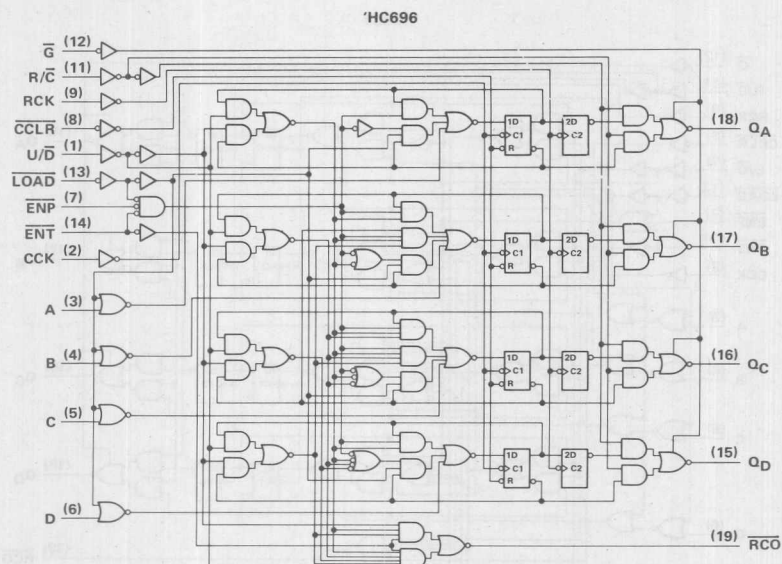


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**ADVANCE INFORMATION**

**TYPES SN54HC696, SN54HC697, SN74HC696, SN74HC697**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

logic diagrams (positive logic)



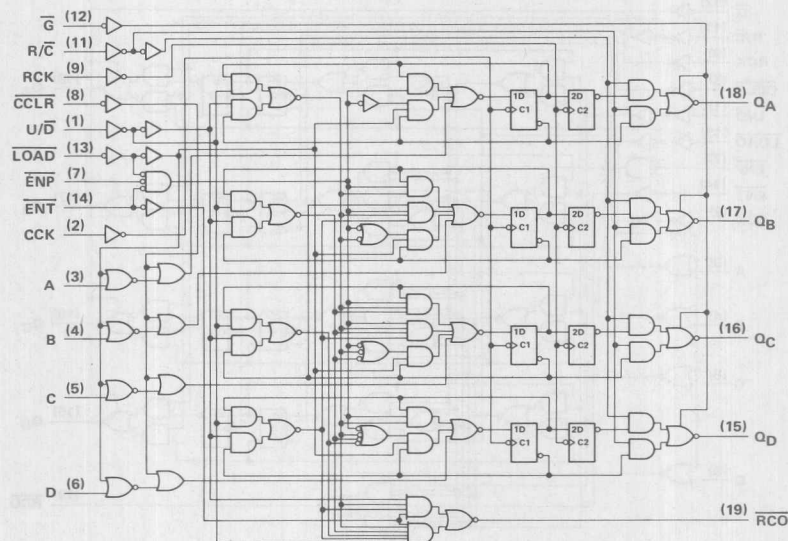
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ADVANCE INFORMATION

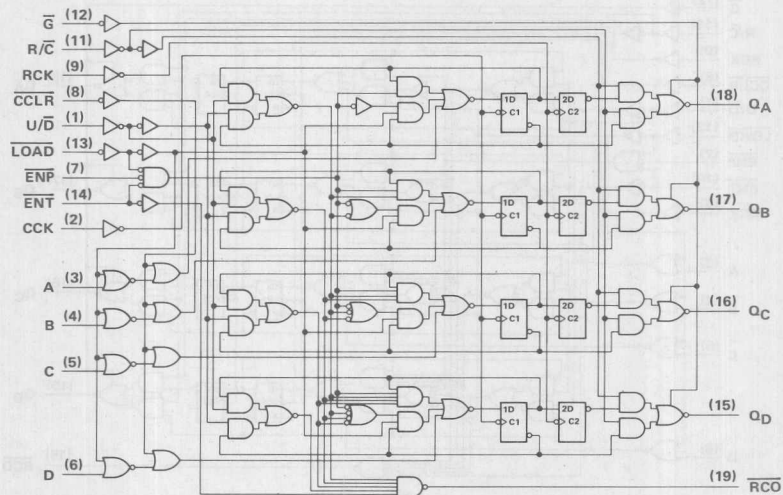
**TYPES SN54HC698, SN54HC699, SN74HC698, SN74HC699**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

logic diagrams (positive logic)

'HC698



'HC699



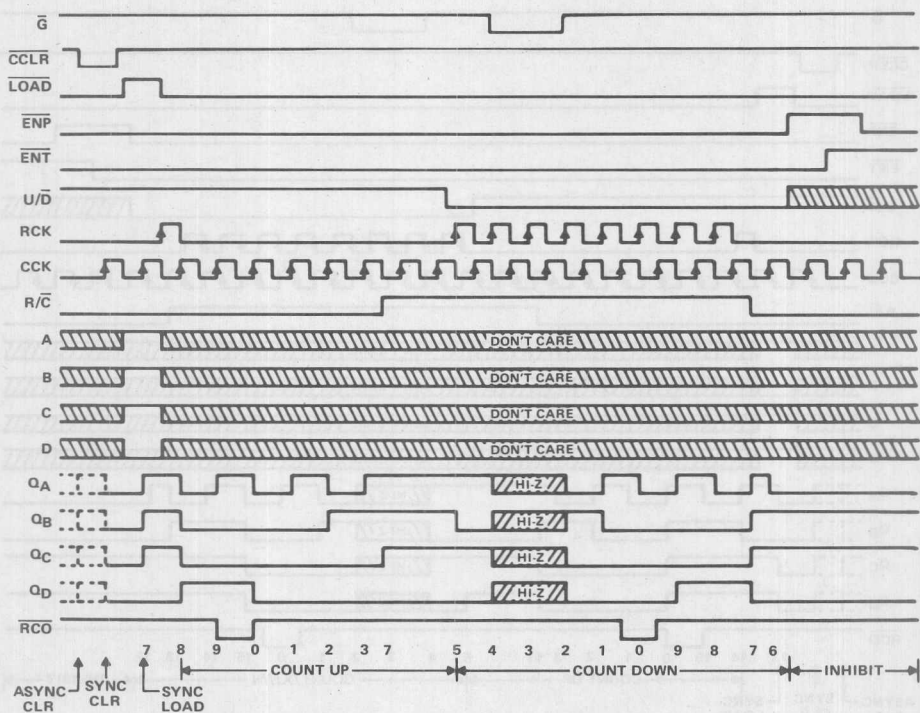
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ADVANCE INFORMATION

**TYPES SN54HC696, SN54HC698, SN74HC696, SN74HC698**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

typical operating sequences

'HC696 DECADE COUNTER, Asynchronous Clear  
 'HC698 DECADE COUNTER, Synchronous Clear



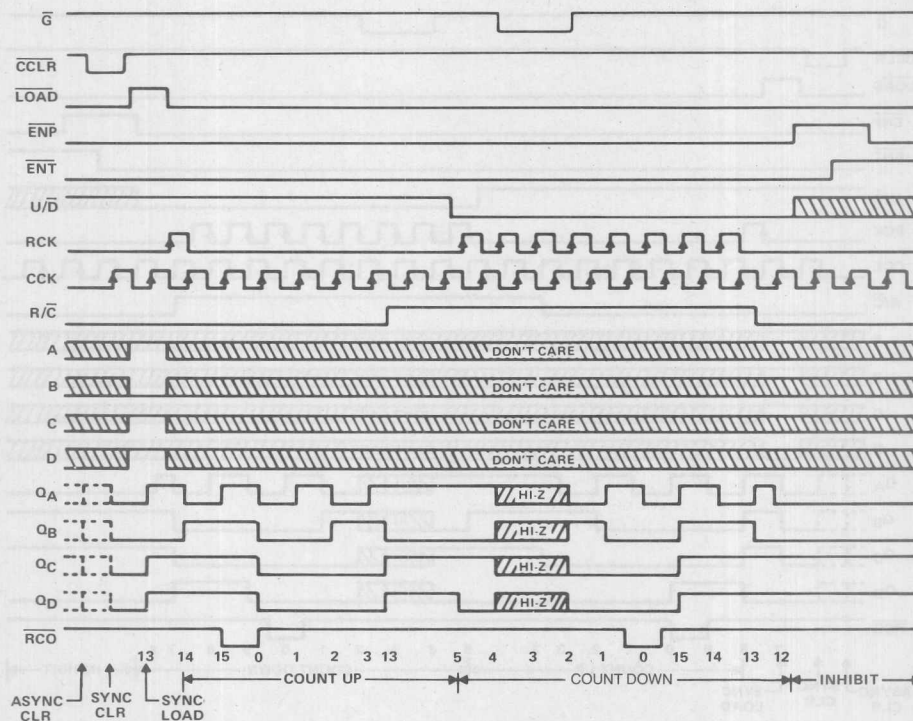
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ADVANCE INFORMATION

**TYPES SN54HC697, SN54HC699, SN74HC697, SN74HC699**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

typical operating sequences

'HC697 BINARY COUNTER, Asynchronous Clear  
 'HC699 BINARY COUNTER, Synchronous Clear



4  
 ADVANCE INFORMATION



**TYPES SN54HC696, SN54HC697, SN74HC696, SN74HC697  
SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS  
AND MULTIPLEXED 3-STATE OUTPUTS**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC696 SN54HC697		SN74HC696 SN74HC697		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CCK↑	$\overline{RCO}$	2 V 4.5 V 6 V		115 23 20						ns
$t_{pd}$	$\overline{ENT}$	$\overline{RCO}$	2 V 4.5 V 6 V		55 11 9						ns
$t_{pd}$	$\overline{CCLR}\downarrow$	$\overline{RCO}$	2 V 4.5 V 6 V		115 23 20						ns
$t_{pd}$	CCK↑	Any Q	2 V 4.5 V 6 V		85 17 14						ns
$t_{pd}$	RCK↑	Any Q	2 V 4.5 V 6 V		85 17 14						ns
$t_{PHL}$	$\overline{CCLR}\downarrow$	Any Q	2 V 4.5 V 6 V		90 18 15						ns
$t_{pd}$	$R/\overline{C}$	Any Q	2 V 4.5 V 6 V		70 14 12						ns
$t_{en}$	$\overline{G}\downarrow$	Any Q	2 V 4.5 V 6 V		70 14 12						ns
$t_{dis}$	$\overline{G}\uparrow$	Any Q	2 V 4.5 V 6 V		95 19 16						ns
$t_t$		Any	2 V 4.5 V 6 V		38 8 6						ns

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION

**TYPES SN54HC698, SN54HC699, SN74HC698, SN74HC699**  
**SYNCHRONOUS UP/DOWN COUNTERS WITH OUTPUT REGISTERS**  
**AND MULTIPLEXED 3-STATE OUTPUTS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC698 SN54HC699		SN74HC698 SN74HC699		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	CCK $\uparrow$	$\overline{RCO}$	2 V		115						ns
			4.5 V		23						
			6 V		20						
$t_{pd}$	$\overline{ENT}$	$\overline{RCO}$	2 V		55						ns
			4.5 V		11						
			6 V		9						
$t_{pd}$	CCK $\uparrow$	Any Q	2 V		95						ns
			4.5 V		19						
			6 V		16						
$t_{pd}$	RCK $\uparrow$	Any Q	2 V		85						ns
			4.5 V		17						
			6 V		14						
$t_{pd}$	R/ $\overline{C}$	Any Q	2 V		70						ns
			4.5 V		14						
			6 V		12						
$t_{en}$	$\overline{G}\downarrow$	Any Q	2 V		70						ns
			4.5 V		14						
			6 V		12						
$t_{dis}$	$\overline{G}\uparrow$	Any Q	2 V		95						ns
			4.5 V		19						
			6 V		16						
$t_t$		Any	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuits and voltage waveforms, see page 1-14.

4

ADVANCE INFORMATION

## TYPES SN54HC4017, SN74HC4017 DECADE COUNTERS/DIVIDERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Carry-Out Output for Cascading
- Divide-by-N Counting
- DC Clock Input Circuit Allows Slow Rise Times
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

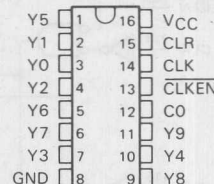
**description**

The 'HC4017 is a 5-stage divide-by-10 Johnson counter with ten decoded outputs and a carry-out bit. High-speed operation and spike-free outputs are obtained by use of the Johnson decade counter configuration.

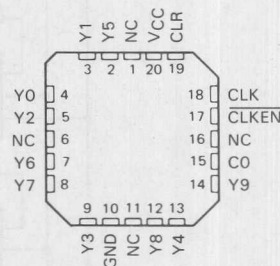
The ten decoded outputs are normally low and go high only at their respective decimal time periods. A high signal on CLR asynchronously clears the decade counter and sets the carry output and Y0 high. With  $\overline{\text{CLKEN}}$  low, the count is advanced on a low-to-high transition at CLK. Alternatively, if CLK is high, the count is advanced on a high-to-low transition at  $\overline{\text{CLKEN}}$ . Each decoded output remains high for one full clock cycle. The carry output C0 is high while Y0, Y1, Y2, Y3, or Y4 is high, then is low while Y5, Y6, Y7, Y8, or Y9 is high.

The SN54HC4017 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4017 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC4017...J PACKAGE  
SN74HC4017...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

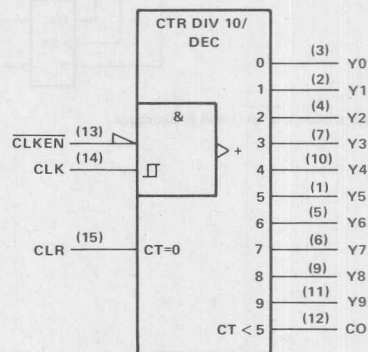


SN54HC4017 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

**logic symbol**



Pin numbers shown are for J and N packages.

### ADVANCE INFORMATION

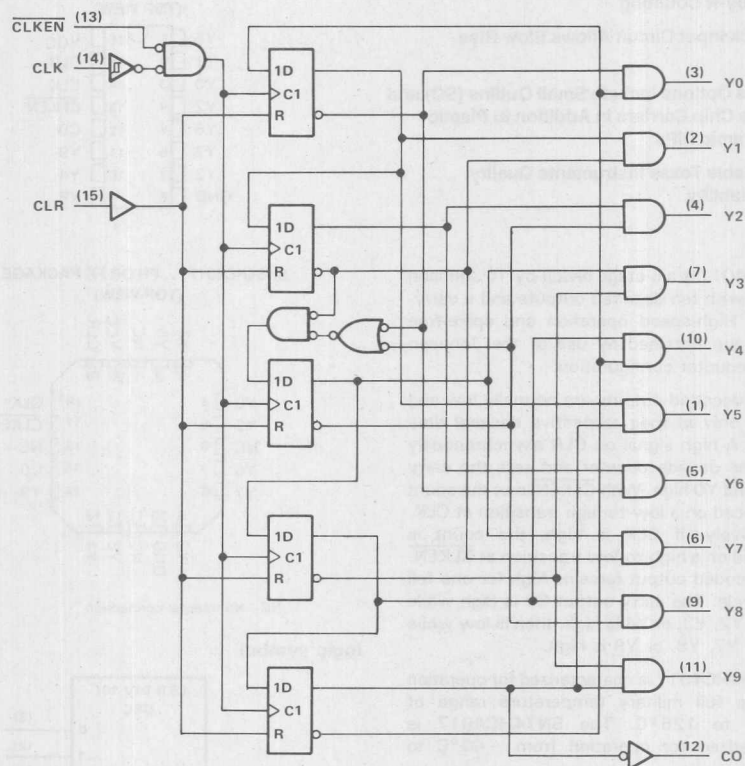
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# TYPES SN54HC4017, SN74HC4017 DECADE COUNTERS/DIVIDERS

logic diagram (positive logic)



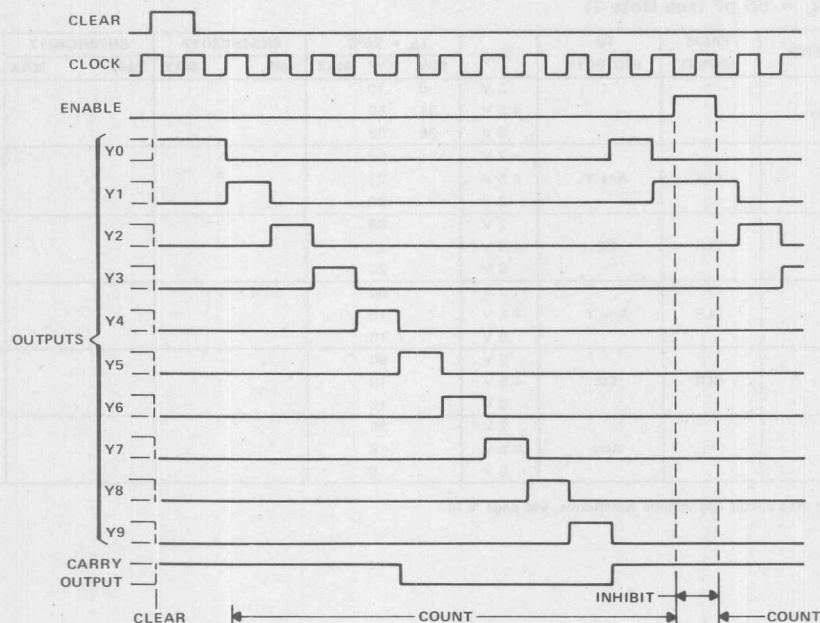
Pin numbers shown are for J and N packages.

4

ADVANCE INFORMATION

# TYPES SN54HC4017, SN74HC4017 DECADE COUNTERS/DIVIDERS

typical clear, count, and inhibit sequences



absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC4017		SN74HC4017		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0	6					MHz
		4.5 V	0	31					
		6 V	0	36					
t <sub>w</sub>	Pulse duration	2 V	80						ns
		4.5 V	16						
		6 V	14						
	CLR high	2 V	80						
		4.5 V	16						
		6 V	14						
t <sub>su</sub>	Setup time, before CLK ↑	2 V	50						ns
		4.5 V	10						
		6 V	9						
	CLR high	2 V	50						
		4.5 V	10						
		6 V	9						

# **TYPES SN54HC4017, SN74HC4017** **DECADE COUNTERS/DIVIDERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC4017		SN74HC4017		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	6	10						MHz
			4.5 V	31	50						
			6 V	36	55						
$t_{\text{pd}}$	CLK	Any Y	2 V		69						ns
			4.5 V		23						
			6 V		20						
$t_{\text{pd}}$	CLK	C0	2 V		69						ns
			4.5 V		23						
			6 V		20						
$t_{\text{pd}}$	CLR	Any Y	2 V		60						ns
			4.5 V		19						
			6 V		16						
$t_{\text{pd}}$	CLR	C0	2 V		60						ns
			4.5 V		19						
			6 V		16						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4022, SN74HC4022 OCTAL COUNTERS/DIVIDERS

D2831, MARCH 1984

- Carry-Out Output for Cascading
- Divide-by-N Counting
- DC Clock Input Circuit Allows Slow Rise Times
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

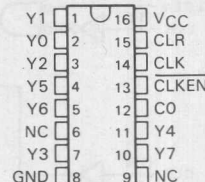
### description

The 'HC4022 is a four-stage divide-by-8 Johnson counter with eight decoded outputs and a carry-out bit. High-speed operation and spike-free outputs are obtained by use of the Johnson octal counter configuration.

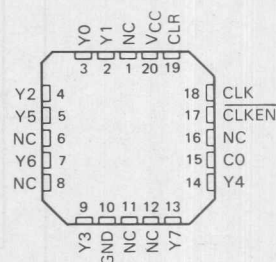
The eight decoded outputs are normally low and go high only at their respective octal time periods. A high signal on CLR asynchronously clears the octal counter and sets the carry output and Y0 high. With CLKEN low, the count is advanced on a low-to-high transition at CLK. Alternatively, if CLK is high, the count is advanced on a high-to-low transition at CLKEN. Each decoded output remains high for one full clock cycle. The carry output C0 is high while Y0, Y1, Y2, or Y3 is high, then is low while Y4, Y5, Y6, or Y7 is high.

The SN54HC4022 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4022 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC4022...J PACKAGE  
SN74HC4022...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

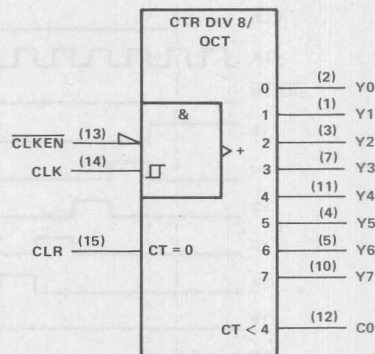


SN54HC4022...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

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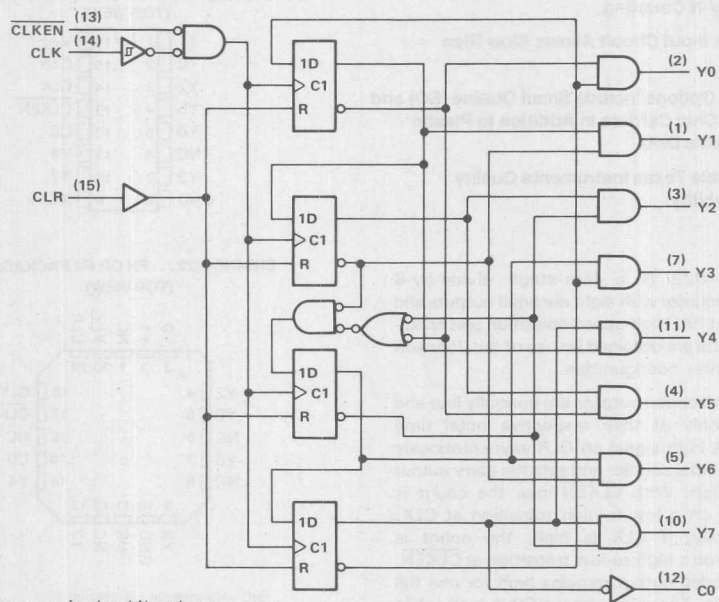
4-143

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ADVANCE INFORMATION

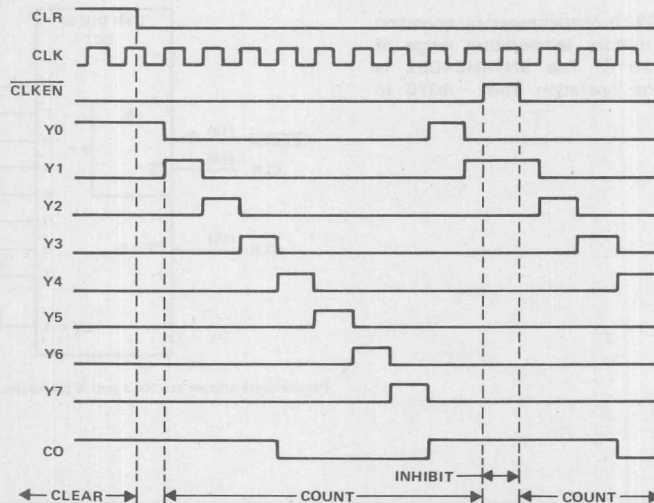
# TYPES SN54HC4022, SN74HC4022 OCTAL COUNTERS/DIVIDERS

logic diagram (positive logic)



Pin numbers shown are for J and N packages.

typical clear, count, and inhibit sequences



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ADVANCE INFORMATION

# TYPES SN54HC4022, SN74HC4022 OCTAL COUNTERS/DIVIDERS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC4022		SN74HC4022		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency	2 V	0	6	0	4.2	0	5	MHz
	4.5 V	0	31	0	21	0	25	
	6 V	0	36	0	25	0	29	
t <sub>w</sub> Pulse duration, CLK high or low, CLKEN high or low, or CLR high	2 V	80		120		100		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, $\overline{\text{CLKEN}}$ low or CLR inactive	2 V	50		75		65		ns
	4.5 V	10		15		13		
	6 V	9		13		11		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25 °C			SN54HC4022		SN74HC4022		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	6	10		4.2		5		MHz
			4.5 V	31	50		21		25		
			6 V	36	55		25		29		
t <sub>pd</sub>	CLK or CLR	Any Y	2 V		70	230		345		290	ns
			4.5 V		24	46		69		58	
			6 V		20	39		59		49	
t <sub>pd</sub>	CLK or CLR	C0	2 V		60	230		345		290	ns
			4.5 V		19	46		69		58	
			6 V		16	39		59		49	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance per counter	No load, T <sub>A</sub> = 25 °C	100 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.

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ADVANCE INFORMATION



- Carry-Out Output for Cascading
- Divide-by-N Counting
- DC Clock Input Circuit Allows Slow Rise Times
- Power-Up Reset
- Pin-Out Compatible with 'HC4022
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

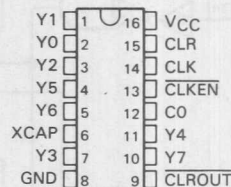
The 'HC7022 is a four-stage divide-by-8 Johnson counter with eight decoded outputs and a carry-out bit. High-speed operation and spike-free outputs are obtained by use of the Johnson octal counter configuration.

The eight decoded outputs are normally low and go high only at their respective octal time periods. A high signal on CLR asynchronously clears the octal counter and sets the carry output and Y0 high. With CLKEN low, the count is advanced on a low-to-high transition at CLK. Alternatively, if CLK is high, the count is advanced on a high-to-low transition at CLKEN. Each decoded output remains high for one full clock cycle. The carry output C0 is high while Y0, Y1, Y2, or Y3 is high, then is low while Y4, Y5, Y6, or Y7 is high.

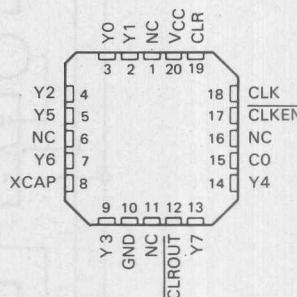
This part is similar to the 'HC4022; the main difference is that it includes a power-up-clear circuit to reset the counter during the power-up of the device. The active-low open-drain clear output, CLROUT, can be used to clear or reset external circuitry. The pulse duration of the power-up reset circuit can be controlled with an external capacitor C<sub>ext</sub> connected to pin XCAP. If XCAP is connected to V<sub>CC</sub>, the power-up reset function is bypassed.

The SN54HC7022 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC7022 is characterized for operation from -40°C to 85°C.

SN54HC7022... J PACKAGE  
SN74HC7022... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

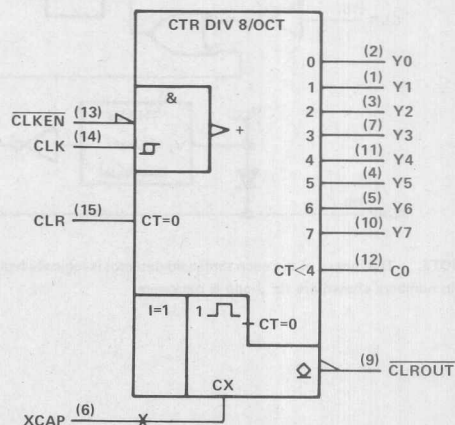


SN54HC7022... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

#### logic symbol



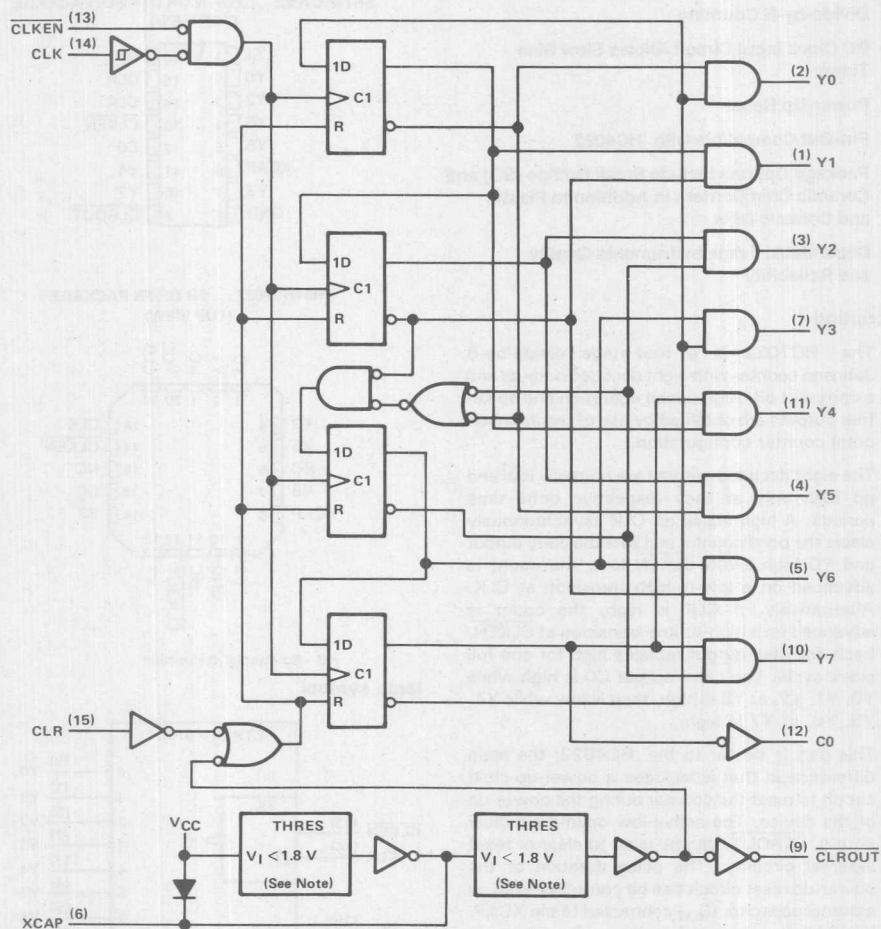
Pin numbers shown are for J and N packages.

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logic diagram (positive logic)

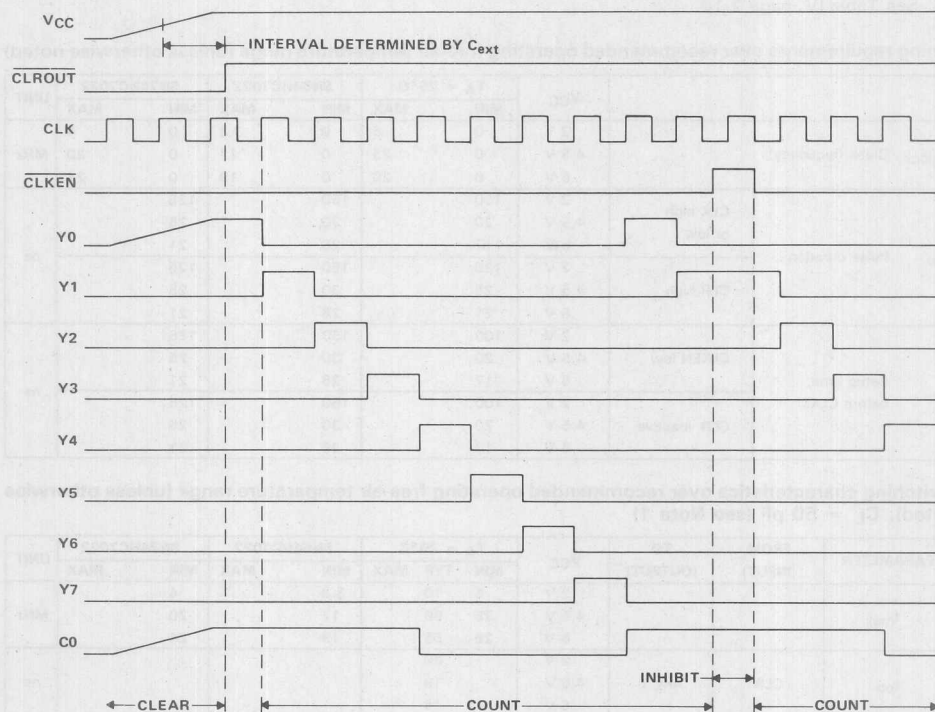


NOTE: The output of the each threshold detector is logically high until the input voltage exceeds the threshold level, typically 1.7 volts. Pin numbers shown are for J and N packages.



TYPES SN54HC7022, SN74HC7022  
OCTAL COUNTERS/DIVIDERS WITH POWER-UP CLEAR

typical power-up clear, count, and inhibit sequences



4

ADVANCE INFORMATION

# **TYPES SN54HC7022, SN74HC7022** **OCTAL COUNTERS/DIVIDERS WITH POWER-UP CLEAR**

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC7022		SN74HC7022		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency	2 V	0		5	0	3.3	0	4	MHz
		4.5 V	0		25	0	17	0	20	
		6 V	0		29	0	19	0	24	
t <sub>w</sub>	Pulse duration	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			26		21		
	CLR high	2 V	125			150		125		
		4.5 V	25			30		25		
		6 V	21			26		21		
t <sub>su</sub>	Setup time, before CLK†	2 V	100			150		125		ns
		4.5 V	20			30		25		
		6 V	17			26		21		
	CLR inactive	2 V	100			150		125		
		4.5 V	20			30		25		
		6 V	17			26		21		

4

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC7022		SN74HC7022		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	10		3.3		4		MHz
			4.5 V	25	50		17		20		
			6 V	29	55		19		24		
t <sub>pd</sub>	CLR	Any Y	2 V		60						ns
			4.5 V		19						
			6 V		16						
t <sub>pd</sub>	CLK	C0	2 V		72						ns
			4.5 V		24						
			6 V		21						
t <sub>pd</sub>	CLK	Any Y	2 V		69						ns
			4.5 V		23						
			6 V		20						
t <sub>pd</sub>	CLR	C0	2 V		60						ns
			4.5 V		19						
			6 V		16						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

ADVANCE INFORMATION

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC7074, SN74HC7074 6-SECTION MULTIFUNCTION (NAND, INVERT, NOR, FLIP-FLOP) CIRCUITS

D2831, MARCH 1984

- Contains D-type Flip-Flops with Preset and Clear, NAND, NOR, and Inverter Gates
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The SN54HC7074 and SN74HC7074 are each comprised of the following sections:

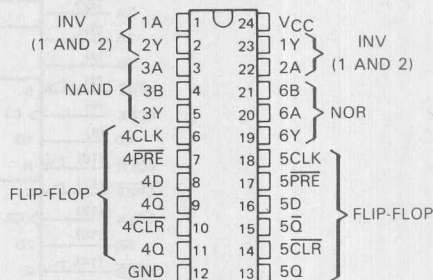
- Two inverters
- One 3-input NOR gate
- One 3-input NAND gate
- Two D-type flip-flops

They perform the Boolean functions shown under the respective function table.

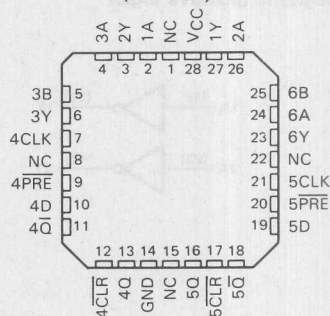
The D-type flip-flops are positive-edge-triggered and are functionally similar to the SN54HC74 and SN74HC74. A low level at the  $\overline{\text{PRE}}$  or  $\overline{\text{CLR}}$  inputs sets or resets the outputs regardless of the levels of the other inputs. When  $\overline{\text{PRE}}$  and  $\overline{\text{CLR}}$  are inactive (high), data at the D input meeting the setup time requirements are transferred to the outputs on the positive-going edge of the clock pulse. Clock triggering occurs at a voltage level and is not directly related to the rise time of the clock pulse. Following the hold time interval, data at the D input may be changed without affecting the levels at the outputs.

The SN54HC7074 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7074 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC7074...JT PACKAGE  
SN74HC7074...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7074...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

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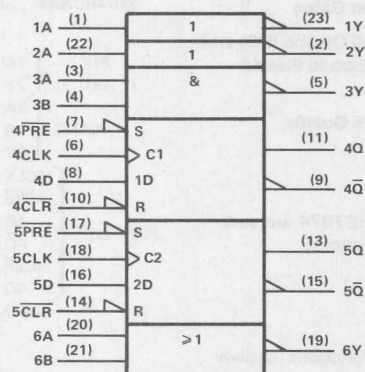
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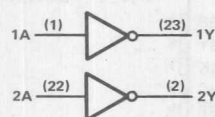
**TYPES SN54HC7074, SN74HC7074**  
**6-SECTION MULTIFUNCTION**  
**(NAND, INVERT, NOR, FLIP-FLOP) CIRCUITS**

logic symbol



logic diagrams (positive logic)

INVERTERS

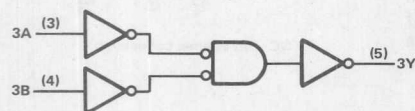


FUNCTION TABLE  
(EACH INVERTER)

INPUT		OUTPUT
A		Y
H		L
L		H

positive logic:  $Y = \bar{A}$

2-INPUT NAND GATE



FUNCTION TABLE

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

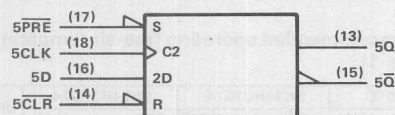
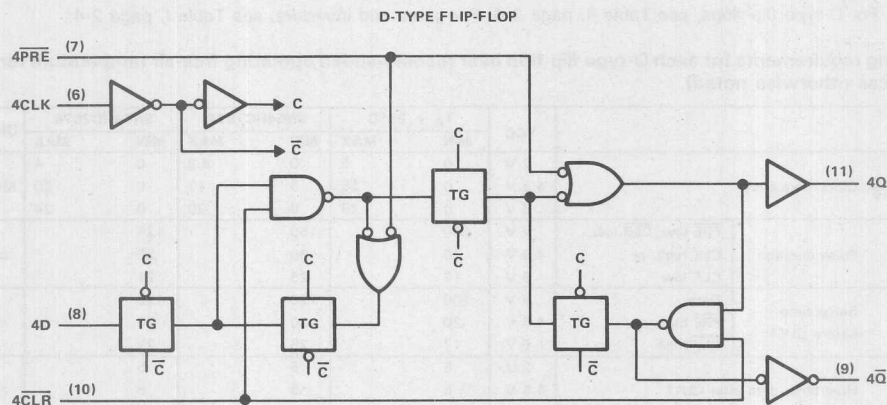
positive logic:  $Y = \bar{A} \cdot \bar{B}$  or  $Y = \overline{A + B}$

Pin numbers shown are for JT and NT packages.

4  
ADVANCE INFORMATION

**TYPES SN54HC7074, SN74HC7074**  
**6-SECTION MULTIFUNCTION**  
**(NAND, INVERT, NOR, FLIP-FLOP) CIRCUITS**

logic diagrams (positive logic)



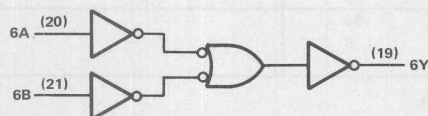
The detail above, and the composite logic symbol to the left, apply to both flip-flops.

**FUNCTION TABLE**  
**(EACH D FLIP-FLOP)**

INPUTS				OUTPUTS	
PRE	CLR	CLK	D	Q	Q̄
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	H*	H*
H	H	↑	H	H	L
H	H	↑	L	L	H
H	H	L	X	Q <sub>0</sub>	Q̄ <sub>0</sub>

\*This configuration is nonstable; i.e., it will not persist when either PRE or CLR returns to the inactive (high) level.

**2-INPUT NOR GATE**



**FUNCTION TABLE**

INPUTS		OUTPUT
A	B	Y
H	X	L
X	H	L
L	L	H

positive logic:  $Y = \overline{A+B}$  or  $Y = \overline{A} \cdot \overline{B}$

Pin numbers shown are for JT and NT packages.

4

ADVANCE INFORMATION

**TYPES SN54HC7074, SN74HC7074**  
**6-SECTION MULTIFUNCTION**  
**(NAND, INVERT, NOR, FLIP-FLOP) CIRCUITS**

absolute maximum ratings, recommended operating conditions, electrical characteristics

For D-type flip-flops, see Table II, page 2-6. For gates and inverters, see Table I, page 2-4.

timing requirements for each D-type flip-flop over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC7074		SN74HC7074		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0		5	0	3.3	0	4	MHz
			4.5 V	0		25	0	17	0	20	
			6 V	0		29	0	20	0	24	
t <sub>w</sub>	Pulse duration	PRE low, CLR low,	2 V	100			150		125		ns
		CLK high, or	4.5 V	20			30		25		
		CLK low	6 V	17			25		21		
t <sub>su</sub>	Setup time before CLK †	Data,	2 V	100			150		125		ns
		PRE high, or	4.5 V	20			30		25		
		CLR high	6 V	17			25		21		
t <sub>h</sub>	Hold time, data after CLK †		2 V	5			5		5		ns
			4.5 V	5			5		5		
			6 V	5			5		5		

switching characteristics for each D-type flip-flop over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

4

ADVANCE INFORMATION

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC7074		SN74HC7074		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>			2 V	5	10		3.3		4		MHz
			4.5 V	25	50		17		20		
			6 V	29	60		20		24		
t <sub>pd</sub>	CLK	Q	2 V		45						ns
			4.5 V		15						
			6 V		13						
t <sub>pd</sub>	CLK	$\bar{Q}$	2 V		45						ns
			4.5 V		15						
			6 V		13						

switching characteristics for gates and inverters over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC7074		SN74HC7074		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A or B	Y	2 V		30						ns
			4.5 V		10						
			6 V		9						
t <sub>t</sub>		Y	2 V		38						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



TYPES SN54HC7074, SN74HC7074  
6-SECTION MULTIFUNCTION  
(NAND, INVERT, NOR, FLIP-FLOP) CIRCUITS

TYPICAL APPLICATION DATA

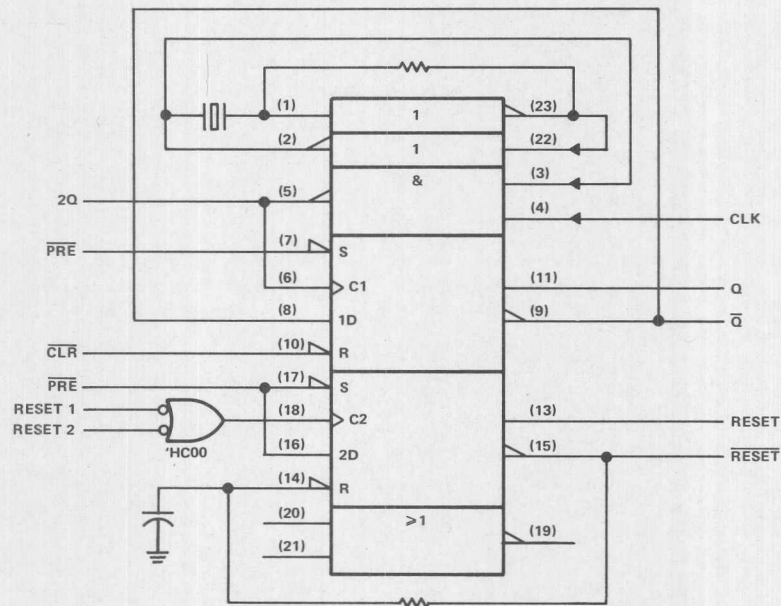


FIGURE 1. CLOCK AND RESET GENERATION FOR MICROPROCESSOR-BASED SYSTEM

4

ADVANCE INFORMATION



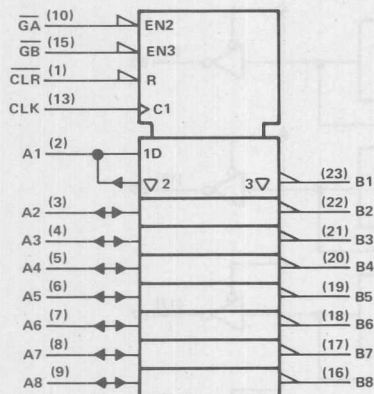
- 8-Bit Bus Drivers with Internal 8-Bit Register
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

These devices consist of bus driver circuits with three-state outputs, D-type flip-flops, clear, and control circuitry arranged for transmission of data directly from the A bus or from the internal register. The A bus is bidirectional and can be used either to load the internal register or to read its contents. Input data is loaded into the register on the low-to-high transition of the clock.

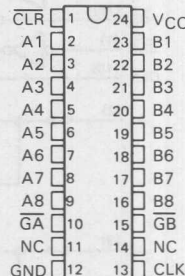
The SN54HC7340 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7340 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

#### logic symbol

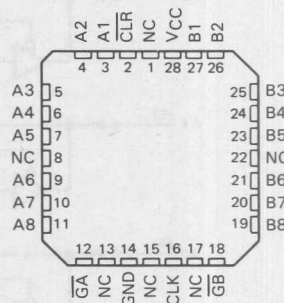


Pin numbers shown are for JT and NT packages.

SN54HC7340...JT PACKAGE  
SN74HC7340...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7340...FH OR FK PACKAGE  
(TOP VIEW)



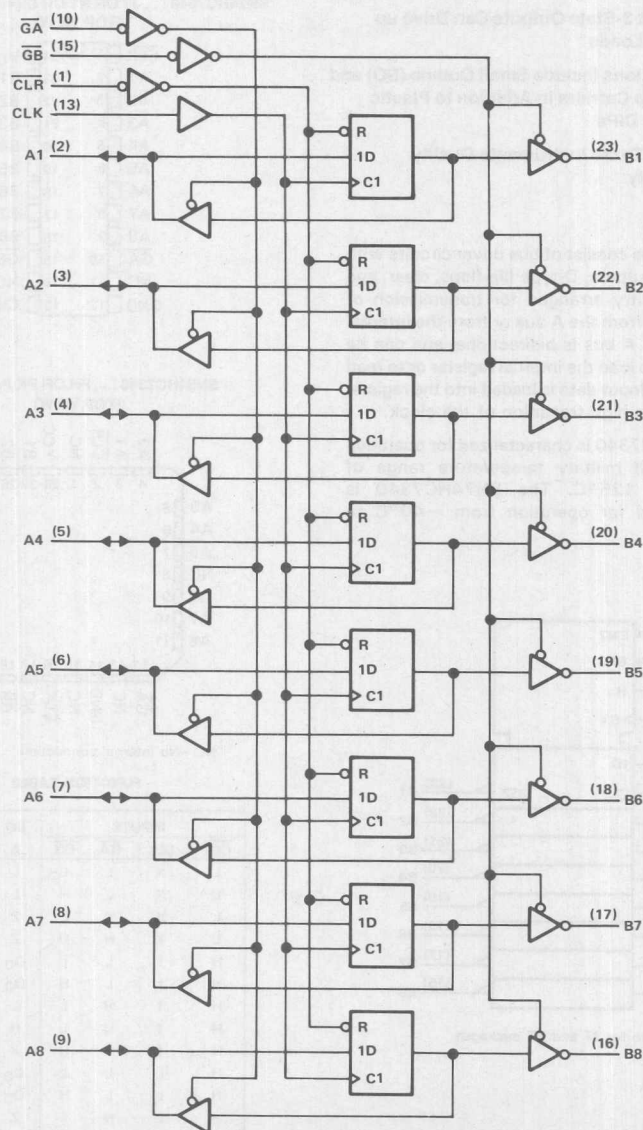
NC—No internal connection

FUNCTION TABLE

INPUTS				I/O	OUTPUT
CLR	CLK	GA	GB		
L	X	L	L	L	H
L	X	L	H	L	Z
L	X	H	L	Z	H
L	X	H	H	Z	Z
H	↑	L	L	Q <sub>0</sub>	Q <sub>0</sub>
H	↑	L	H	Q <sub>0</sub>	Z
H	↑	H	L	L	H
H	↑	H	H	H	L
H	↑	H	H	X	Z
H	L	L	L	Q <sub>0</sub>	Q <sub>0</sub>
H	L	L	H	Q <sub>0</sub>	Z
H	L	H	L	Z	Q <sub>0</sub>
H	L	H	H	Z	Z

# TYPES SN54HC7340, SN74HC7340 OCTAL BUS DRIVERS WITH BIDIRECTIONAL REGISTERS

logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

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ADVANCE INFORMATION

# TYPES SN54HC7340, SN74HC7340 OCTAL BUS DRIVERS WITH BIDIRECTIONAL REGISTERS

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

			V <sub>CC</sub>	T <sub>A</sub> = 25 °C		SN54HC7340		SN74HC7340		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency		2 V	0	5	0	3.3	0	4	MHz
			4.5 V	0	25	0	17	0	20	
			6 V	0	29	0	19	0	24	
t <sub>w</sub>	Pulse duration	Clock high or low	2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
	Clear low	2 V	100		150		125		ns	
		4.5 V	20		30		25			
		6 V	17		26		21			
t <sub>su</sub>	Setup time before CLK †	Data	2 V	100		150		125		ns
			4.5 V	20		30		25		
			6 V	17		26		21		
	Clear inactive	2 V	100		150		125		ns	
		4.5 V	20		30		25			
		6 V	17		26		21			
t <sub>h</sub>	Hold time, data after CLK †		2 V	0		0		0	ns	
			4.5 V	0		0		0		
			6 V	0		0		0		

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ADVANCE INFORMATION

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC7340		SN74HC7340		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$			2 V	5			3.3		4		MHz
			4.5 V	25			17		20		
			6 V	29			19		24		
$t_{\text{pd}}$	CLK	Any	2 V		72						ns
			4.5 V		24						
			6 V		21						
$t_{\text{PHL}}$	$\overline{\text{CLR}}$	Any	2 V		69						ns
			4.5 V		23						
			6 V		20						
$t_{\text{en}}$	$\overline{\text{GA}}$ or $\overline{\text{GB}}$	A or B	2 V		48						ns
			4.5 V		16						
			6 V		14						
$t_{\text{dis}}$	$\overline{\text{GA}}$ or $\overline{\text{GB}}$	A or B	2 V		51						ns
			4.5 V		17						
			6 V		15						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

4

$C_{\text{pd}}$	Power dissipation capacitance	No load, $T_A = 25^\circ\text{C}$	50 pF typ
-----------------	-------------------------------	-----------------------------------	-----------

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 150$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC7340		SN74HC7340		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{\text{pd}}$	CLK	Any	2 V		93						ns
			4.5 V		31						
			6 V		27						
$t_{\text{PHL}}$	$\overline{\text{CLR}}$	Any	2 V		87						ns
			4.5 V		29						
			6 V		26						
$t_{\text{en}}$	$\overline{\text{GA}}$ or $\overline{\text{GB}}$	A or B	2 V		60						ns
			4.5 V		20						
			6 V		17						
$t_{\text{dis}}$	$\overline{\text{GA}}$ or $\overline{\text{GB}}$	A or B	2 V		63						ns
			4.5 V		21						
			6 V		18						
$t_t$		Any	2 V		60						ns
			4.5 V		17						
			6 V		14						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

ADVANCE INFORMATION



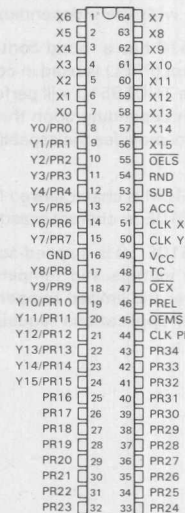
- 16-Bit by 16-Bit Parallel Multiplication/Accumulation
- 35-Bit-Wide Accumulator
- Inputs are TTL-Voltage Compatible
- Outputs Capable of Driving up to 10 LSTTL Loads
- Single 5-V Power Supply
- Low Power Dissipation . . . 150 mW Typical
- Pin-for-Pin Compatible with TRW TDC1010J and AM29510 (DIP only)
- High-Speed Twin-Well CMOS Process
- Package Options Include Ceramic Chip Carriers and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

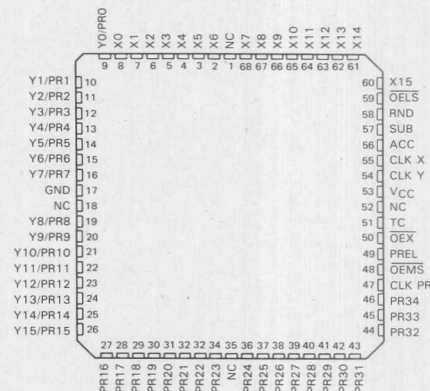
The THCT9510 is a TTL-voltage-compatible, low-power, high-speed 16-bit by 16-bit multiplier/accumulator for digital signal processing, digital filters, fast Fourier transformations, array processing, and microprocessor throughput enhancement. These devices operate at the same speed as the TRW TDC1010J but dissipate 20 times less power. The lower power dissipation causes the differences between junction and ambient temperatures to be minimized and, therefore, eliminates the heat-sink requirements and increases reliability. High-speed is achieved by using a modified Booth algorithm, a feed-forward carry circuit, and a conditional sum adder that enhances the final adder stage of the multiplier.

The THCT9510 inputs consist of three registers, a 16-bit X input, a 16-bit Y input, and an input control register. The 35-bit output product register consists of a 16-bit most-significant-product (MSP) bus, a 16-bit least-significant-product (LSP) bus that is shared with the 16-bit Y input bus, and a 3-bit extended-product (XTP) bus (PR32 through PR34); see the functional block diagram. The input registers are

**JD DUAL-IN-LINE PACKAGE  
(TOP VIEW)**



**FK CHIP-CARRIER PACKAGE  
(TOP VIEW)**



NC—No internal connection.



Caution. These devices have limited built-in gate protection. The leads should be shorted together or the device, placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**ADVANCE INFORMATION**  
This document contains information on a new product. Specifications are subject to change without notice.

**TEXAS  
INSTRUMENTS**

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## THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

independently controlled by CLK X and CLK Y, and the product registers are D-type positive-edge-triggered flip-flops. Separate three-state output enables are provided for each output product register. These, in combination with the independent input clocks, allow operation on a microprocessor bus.

The THCT9510 has a round control (RND) that rounds the product to the 19 most-significant bits. The preload control (PREL) is used in conjunction with the output enables to initialize the contents of the output registers. The THCT9510 will perform multiplication and addition, multiplication and subtraction, or straight multiplication depending upon the states of the accumulate control (ACC) and subtractor control (SUB). The TC control provides the capability of formatting the input data to be either two's complement or unsigned magnitude.

The THCT9510M is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The THCT9510E is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

The THCT9510E-10 is a speed-screen version of the THCT9510E and meets all specifications as shown over the full voltage and temperature ranges. In addition, the THCT9510E-10 has faster guaranteed operation over the limited temperature range of  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ , and the limited voltage range of 4.75 V to 5.25 V for applications requiring this improved performance.

### 4

#### ADVANCE INFORMATION

**THCT9510M, THCT9510E**  
**16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR**

**PIN FUNCTIONAL DESCRIPTION**

PIN	PIN NAME	FUNCTIONAL DESCRIPTION
56–64, 1–7	X15 thru X0	X data inputs, X15 is the most-significant bit. The data is loaded into the X register on the rising edge of CLKX.
8–15, 17–24	Y0/PRO thru Y15/PR15	I/O ports for least significant product (LSP) bits of output product register, input ports for Y data. Y0/PRO is the least significant bit. The mode is controlled by the PREL and OEMS pins.
25–43	PR16 thru PR34	I/O ports for output product register bits. PR16 through PR31 are the most-significant product (MSP) bits. PR32 through PR34 are the extended product (XTP) bits. The mode is controlled by PREL, OELS, OEX.
44	CLK PR	Product clock input. On the low-to-high transition, latches the LSP, MSP, and XTP into the output product register.
45	OEMS	Active-low output enable for MSP output product register. When high, causes the PR31 through PR16 outputs to be in the high-impedance state.
46	PREL	Preload control. When high, the output product register's outputs are disabled. When an output enable (OELS, OEMS, OEX) is high, preload data can be entered into the output product register from the PR I/O lines on the rising edge of CLK PR.
47	OEX	Active-low output enable for XTP output product register. When high, causes the PR32 through PR34 outputs to be in the high-impedance state.
48	TC	Two's complement control. When TC is high, the input data is in two's complement format. When TC is low, the input data is in unsigned magnitude format. The TC signal is loaded into the control register on the rising edge of CLK X or CLK Y.
50	CLK Y	Y clock input. On the low-to-high transition, clocks data in from the Y inputs.
51	CLK X	X clock input. On the low-to-high transition, clocks data in from the X inputs.
52	ACC	Accumulator control. When ACC is high and SUB is low, the content of the output product register is added to the next product generated. The sum is then placed in the output product register on the rising edge of CLK PR. When ACC is low, the product is stored directly into the output register on the rising edge of CLK PR. The ACC signal is loaded into the control register at the rising edge of CLK X or CLK Y.
53	SUB	Subtraction control. When SUB and ACC are high, the content of the output product register is subtracted from the next product generated. The result is then placed in the output product register on the rising edge of CLK PR. When SUB is low and ACC is high, the addition operation is performed instead of subtraction. When ACC is low, SUB is a "Don't Care". The SUB signal is loaded into the control register on the rising edge of CLK X or CLK Y.
54	RND	Round control. When high, causes the product of the X and Y inputs to be rounded to the 19 most-significant bits. The RND signal is loaded into the control register on the rising edge of CLK X or CLK Y.
55	OELS	Active-low output enable for LSP output product register. When high, causes the PR0 through PR15 outputs to be in the high-impedance state.

Pin numbers shown are for the JD package.

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**ADVANCE INFORMATION**

# THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

PRELOAD FUNCTION TABLE

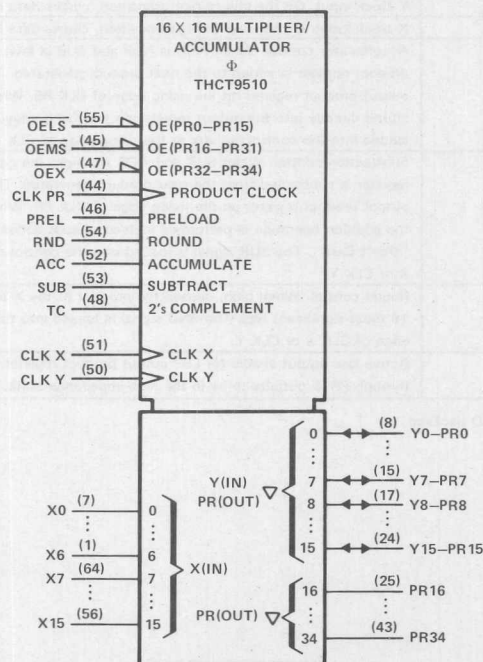
PREL	OEX	OEMS	OELS	XTP	MSP	LSP
L	L	L	L	(PR32-PR34)	(PR16-PR31)	(PRO-PR15)
L	L	L	H	(PR32-PR34)	(PR16-PR31)	Z
L	L	H	L	(PR32-PR34)	Z	(PRO-PR15)
L	L	H	H	(PR32-PR34)	Z	Z
L	H	L	L	Z	(PR16-PR31)	(PRO-PR15)
L	H	L	H	Z	(PR16-PR31)	Z
L	H	H	L	Z	Z	(PRO-PR15)
L	H	H	H	Z	Z	Z
H	L	L	L	Z	Z	Z
H	L	L	H	Z	Z	PL
H	L	H	L	Z	PL	Z
H	L	H	H	Z	PL	PL
H	H	L	L	PL	Z	Z
H	H	L	H	PL	Z	PL
H	H	H	L	PL	PL	Z
H	H	H	H	PL	PL	PL

PL = Output buffers at high impedance or output disabled. Preload data supplied externally at output pins will be loaded into the output register on the rising edge of CLK PR.

logic symbol

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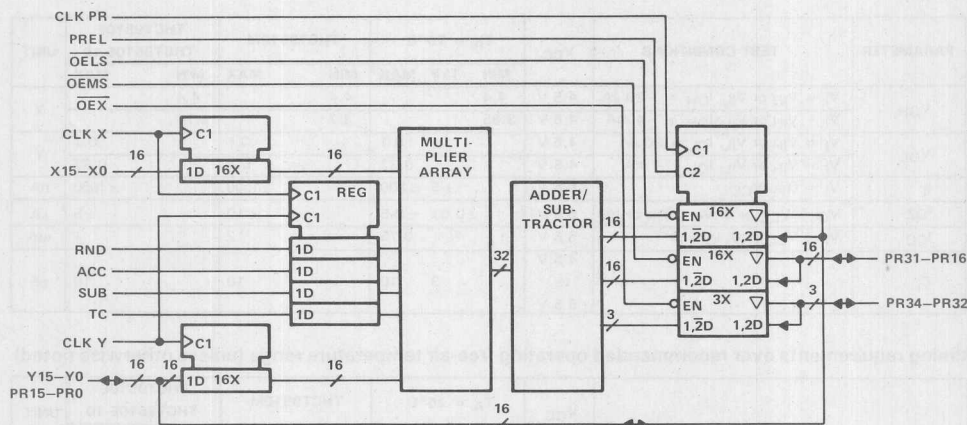
ADVANCE INFORMATION



Pin numbers shown are for the JD package.

# THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

logic diagram (positive logic)



Pin numbers shown are for the JD package.

## absolute maximum ratings over operating free-air temperature†

Supply voltage range, $V_{CC}$	-0.5 V to 7 V
Input diode current, $I_{IK}$ ( $V_I < 0$ or $V_I > V_{CC}$ )	$\pm 20$ mA
Output diode current, $I_{OK}$ ( $V_O < 0$ or $V_O > V_{CC}$ )	$\pm 20$ mA
Continuous output current, $I_O$ ( $V_O = 0$ to $V_{CC}$ )	$\pm 25$ mA
Continuous current through $V_{CC}$ or GND pins	$\pm 50$ mA
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds	300°C
Storage temperature range	-65°C to 150°C

†Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## recommended operating conditions

			THCT9510M			THCT9510E THCT9510E-10			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
$V_{CC}$	Supply voltage		4.5	5	5.5	4.5	5	5.5	V
$V_{IH}$	High-level input voltage	$V_{CC} = 4.5$ V to 5.5 V	2			2			V
$V_{IL}$	Low-level input voltage	$V_{CC} = 4.5$ V to 5.5 V	0	0.8		0	0.8		V
$V_I$	Input voltage		0	$V_{CC}$		0	$V_{CC}$		V
$V_O$	Output voltage		0	$V_{CC}$		0	$V_{CC}$		V
$t_t$	Input transition (rise and fall) times		0	500		0	500		ns
$T_A$	Operating free-air temperature		-55	125		-40	85		°C



# THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	T <sub>A</sub> = 25°C			THCT9510M		THCT9510E THCT9510E-10		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
V <sub>OH</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -20 μA	4.5 V	4.4			4.4		4.4		V
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = -4 mA	4.5 V	3.86			3.7		3.76		
V <sub>OL</sub>	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 20 μA	4.5 V			0.1		0.1		0.1	V
	V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OL</sub> = 4 mA	4.5 V			0.32		0.4		0.37	
I <sub>I</sub>	V <sub>I</sub> = 0 to V <sub>CC</sub>	5.5 V		± 5	± 100		± 1000		± 1000	nA
I <sub>OZ</sub>	V <sub>O</sub> = V <sub>CC</sub> or 0, V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>	5.5 V		± 0.01	± 0.5		± 10		± 5	μA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or 0, I <sub>O</sub> = 0	5.5 V			0.75		2		1	mA
C <sub>i</sub>		4.5 V								pF
		5.5 V		3	10		10		10	

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

	V <sub>CC</sub>	T <sub>A</sub> = 25°C		THCT9510M		THCT9510E THCT9510E-10		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration	4.5 V	20		30		25		ns
	5.5 V	20		30		25		
t <sub>su</sub> Setup time	4.5 V	23		30		25		ns
	5.5 V	23		30		25		
t <sub>h</sub> Hold time	4.5 V	0		0		0		ns
	5.5 V	0		0		0		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF

PARAMETER		V <sub>CC</sub>	T <sub>A</sub> = 25°C		THCT9510M		THCT9510E THCT9510E-10		UNIT
			MIN	TYP	MAX	MIN	MAX	MIN	
t <sub>pd</sub>	Propagation delay time	4.5 V	50		65		60		ns
		5.5 V	45		60		55		
t <sub>en</sub>	Enable time	4.5 V	50		65		60		ns
		5.5 V	45		60		55		
t <sub>dis</sub>	Disable time	4.5 V	45		60		55		ns
		5.5 V	40		55		50		
t <sub>macc</sub>	Multiply/accumulate time	4.5 V	105		160		140		ns
		5.5 V	95		140		120		
C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C				750 pF typ			

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ADVANCE INFORMATION



# THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

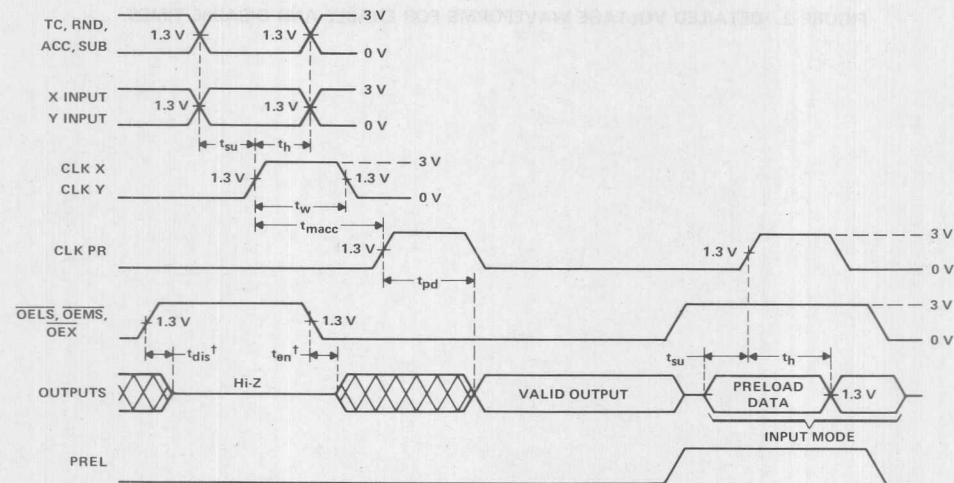
timing requirements over 0°C to 70°C free-air operating temperature range

	VCC	THCT9510E		THCT9510E-10		UNIT
		MIN	MAX	MIN	MAX	
$t_w$ Pulse duration	4.75	25		25		ns
$t_{su}$ Setup time	4.75	25		15		ns
$t_h$ Hold time	4.75	0		0		ns

switching characteristics over 0°C to 70°C free-air operating temperature range,  $C_L = 50$  pF

PARAMETER	VCC	THCT9510E		THCT9510E-10		UNIT
		MIN	MAX	MIN	MAX	
$t_{pd}$ Propagation delay time	4.75		58		55	ns
$t_{en}$ Enable time	4.75		58		55	ns
$t_{dis}$ Disable time	4.75		53		50	ns
$t_{macc}$ Multiply/accumulate time	4.75		130		100	ns

## PARAMETER MEASUREMENT INFORMATION



<sup>†</sup>The measurement points for enable and disable times are as shown in Figure 2.

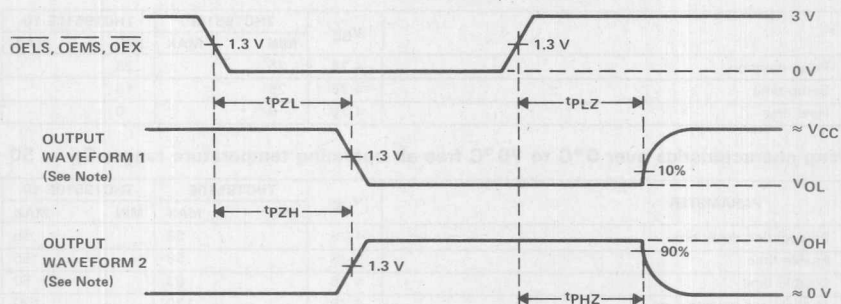
FIGURE 1. VOLTAGE WAVEFORMS

4

ADVANCE INFORMATION

**THCT9510M, THCT9510E**  
**16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR**

**PARAMETER MEASUREMENT INFORMATION**



NOTE: Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.

**FIGURE 2. DETAILED VOLTAGE WAVEFORMS FOR ENABLE AND DISABLE TIMES**

**4**

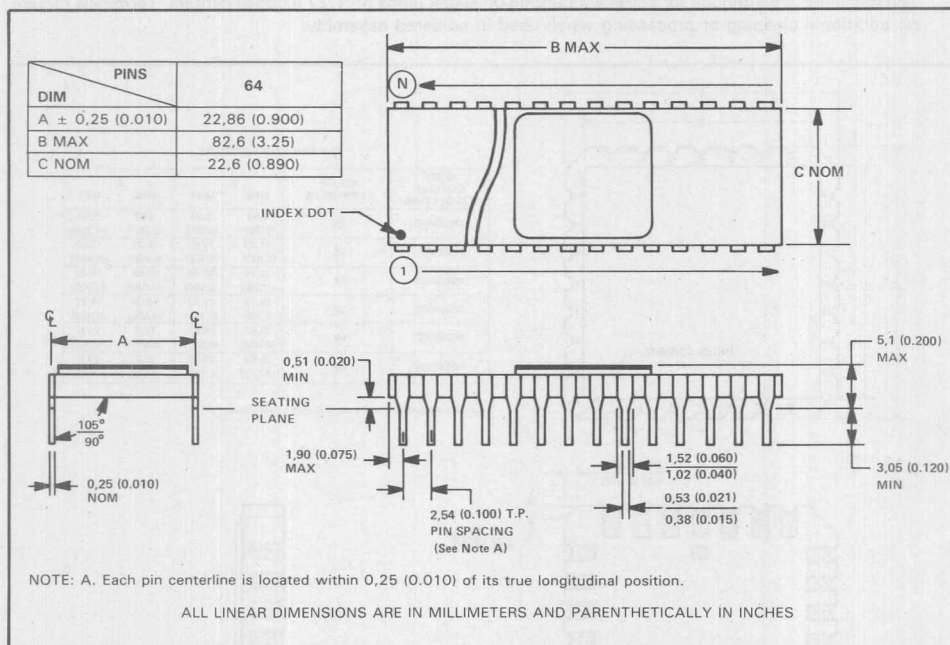
**ADVANCE INFORMATION**

THCT9510M, THCT9510E  
16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

MECHANICAL DATA

64-pin JD package (side brazed)

This is a hermetically sealed ceramic package with a metal cap and side-brazed gold-plated leads.



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ADVANCE INFORMATION

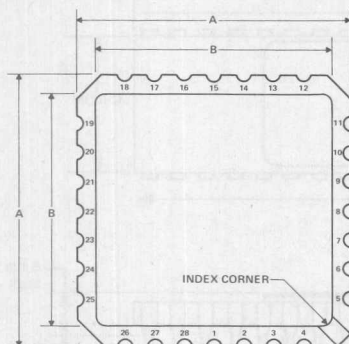
# THCT9510M, THCT9510E 16-BIT BY 16-BIT MULTIPLIER/ACCUMULATOR

## MECHANICAL DATA

### FK ceramic chip carrier packages

The FK package is hermetically sealed with a three-layer ceramic base, metal lid, and braze seal.

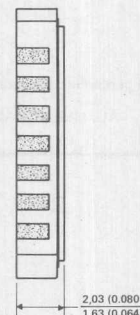
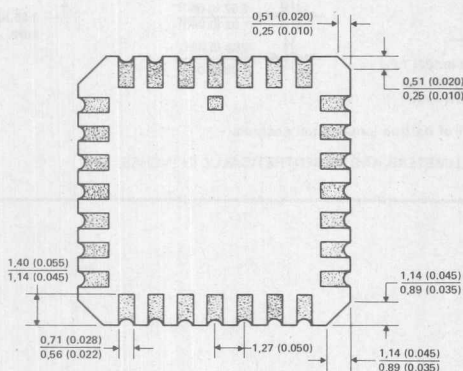
The packages are intended for surface mounting on solder lands on 1,27 (0.050) centers. Terminals require no additional cleaning or processing when used in soldered assembly.



CERAMIC CHIP CARRIERS

JEDEC OUTLINE DESIGNATION*	NO. OF TERMINALS	MIN A MAX		MIN B MAX	
		MIN	MAX	MIN	MAX
MS004CB	20	8,69 (0.342)	9,09 (0.358)	7,80 (0.307)	9,09 (0.358)
MS004CC	28	11,23 (0.442)	11,63 (0.458)	10,31 (0.406)	11,63 (0.458)
MS004CD	44	16,26 (0.640)	16,76 (0.660)	12,58 (0.495)	14,22 (0.560)
MS004CE	52	18,78 (0.739)	19,32 (0.761)	12,58 (0.495)	14,22 (0.560)
MS004CF	68	23,83 (0.938)	24,43 (0.962)	12,6 (0.495)	21,8 (0.862)
MS004CG	84	28,83 (1.135)	29,59 (1.165)	12,6 (0.495)	27,0 (1.065)

\*All dimensions and notes for the specified JEDEC outline apply.



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

## 4 ADVANCE INFORMATION

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**GENERAL INFORMATION**

**1**

**RATINGS AND CHARACTERISTICS**

**2**

**HCMOS DEVICES**

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**9**

### PRODUCT PREVIEW

This section contains information on products under development in the formative or design phase. Characteristic data and other specifications are DESIGN GOALS. Texas Instruments reserves the right to change or discontinue these products without notice.



- D-C Triggered by Active-High or Active-Low Inputs
- Retriggerable for Very Long Output Pulses, Up to 100% Duty Cycle
- Overriding Clear Terminates Output Pulse
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

#### description

These d-c triggered multivibrators feature output pulse duration control by three methods. The basic pulse duration is programmed by selection of external resistance and capacitance values. Once triggered, the basic pulse duration may be extended by retriggering the gated low-level-active (A) or high-level-active (B) inputs, or be reduced by use of the overriding clear. Figure 1 illustrates pulse control by retriggering and early clear.

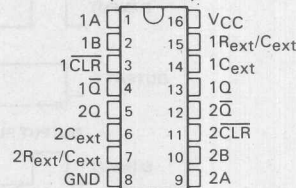
The SN54HC123 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC123 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE

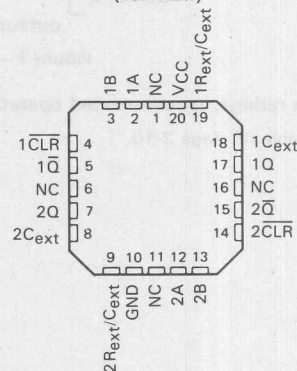
INPUTS			OUTPUTS	
CLEAR	A	B	Q	$\bar{Q}$
L	X	X	L	H
X	H	X	$L^{\dagger}$	$H^{\dagger}$
X	X	L	$L^{\dagger}$	$H^{\dagger}$
H	L	$\uparrow$	$\square$	$\square$
H	$\downarrow$	H	$\square$	$\square$
$\uparrow$	L	H	$\square$	$\square$

$\dagger$  The second and third lines each indicate the logic levels the outputs will take on after the completion of any pulse already started.

SN54HC123 ... J PACKAGE  
SN74HC123 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

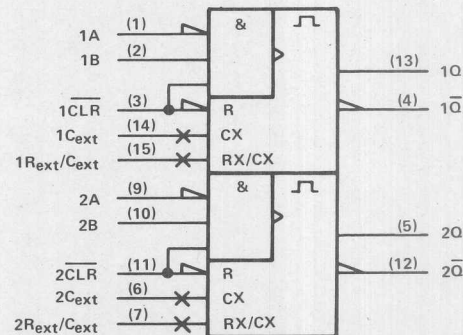


SN54HC123 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

#### logic symbol



Pin numbers shown are for J and N packages.

#### PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.



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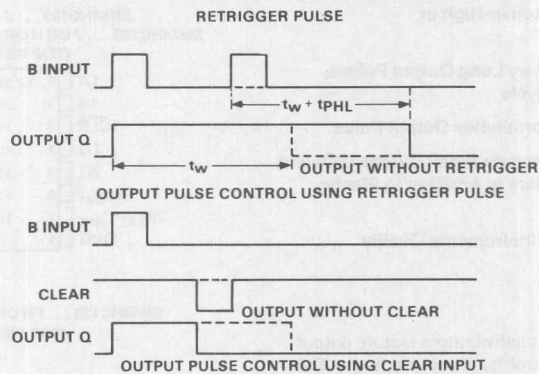


FIGURE 1 — TYPICAL INPUT/OUTPUT PULSES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

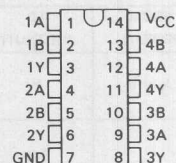
# **HIGH-SPEED CMOS LOGIC**

# **TYPES SN54HC132, SN74HC132 SCHMITT-TRIGGER POSITIVE-NAND GATES WITH TOTEM-POLE OUTPUTS**

D2684, DECEMBER 1982—REVISED MARCH 1984

- Operation from Very Slow Transitions
- Temperature-Compensated Threshold Levels
- High Noise Immunity
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC132... J PACKAGE  
SN74HC132... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



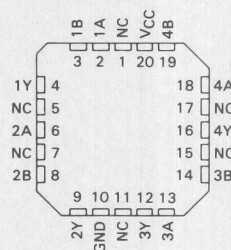
## **description**

Each circuit functions as a NAND gate, but because of the Schmitt action, it has different input threshold levels for positive- and negative-going signals. It performs the Boolean function  $Y = A \cdot B$  or  $Y = \bar{A} + \bar{B}$  in positive logic.

These circuits are temperature compensated and can be triggered from the slowest of input ramps and still give clean jitter-free output signals.

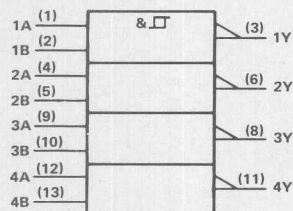
The SN54HC132 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC132 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC132... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

## **logic symbol**



Pin numbers shown are for J and N packages.

FUNCTION TABLE (each gate)

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

## **maximum ratings, recommended operating conditions, and electrical characteristics**

See Table I, page 2-4.

## **PRODUCT PREVIEW**

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

TEXAS  
INSTRUMENTS

Copyright © 1982, Texas Instruments Incorporated

# TYPES SN54HC132, SN74HC132 SCHMITT-TRIGGER POSITIVE-NAND GATES WITH TOTEM-POLE OUTPUTS

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC132		SN74HC132		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40						ns
			4.5 V		13						
			6 V		11						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

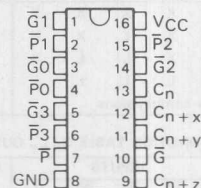
# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC182, SN74HC182 LOOK-AHEAD CARRY GENERATOR

D2804, MARCH 1984

- Offers Carry Functions in a Compatible Form for Direct Connections to the ALU
- Cascadable to Perform Look-Ahead Across n-Bit Adders
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC182...J PACKAGE  
SN74HC182...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



PIN DESIGNATIONS

ALTERNATIVE	DESIGNATIONS†	FUNCTION
$\bar{G}0, \bar{G}1, \bar{G}2, \bar{G}3$	G0, G1, G2, G3	Carry Generate Inputs
$\bar{P}0, \bar{P}1, \bar{P}2, \bar{P}3$	P0, P1, P2, P3	Carry Propagate Inputs
$C_n$	$\bar{C}_n$	Carry Input
$C_{n+x}, C_{n+y}, C_{n+z}$	$\bar{C}_{n+x}, \bar{C}_{n+y}, \bar{C}_{n+z}$	Carry Outputs
$\bar{G}$	Y	Carry Generate Output
$\bar{P}$	X	Carry Propagate Output
$V_{CC}$		Supply Voltage
GND		Ground

† Interpretations are illustrated in connection with the Function Tables for the 'HC181 and 'HC881.

## description

The 'HC182 look-ahead carry generators are capable of anticipating a carry across four binary adders or group of adders. They are cascadable to perform full look-ahead across n-bit adders.

This generator, when used in conjunction with the 'HC181 or 'HC881 Arithmetic Logic Unit ALU, provides high-speed carry look-ahead capability for any word length. The 'HC182 generates the look-ahead (anticipated carry) across a group of four ALUs. In addition, other carry look-ahead circuits may be employed to anticipate carry-across sections of four look-ahead packages up to n-bits.

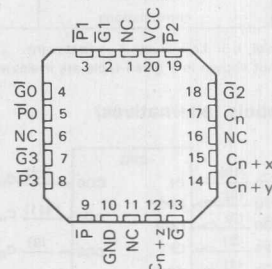
The carry functions (inputs, outputs, generate, and propagate) of the look-ahead generators are implemented in the compatible forms for direct connections to the ALU. Reinterpretations of carry functions as explained on the 'HC181 and 'HC881 data sheet are also applicable to and compatible with the look-ahead generator. Logic equations for the 'HC182 are:

$$\begin{aligned}
 C_{n+x} &= G0 + P0 C_n \\
 C_{n+y} &= G1 + P1 G0 + P1 P0 C_n \\
 C_{n+z} &= G2 + P2 G1 + P2 P1 G0 + P2 P1 P0 C_n \quad \text{or} \quad \begin{aligned} \bar{C}_{n+x} &= \bar{Y}0 (X0 + C_n) \\ \bar{C}_{n+y} &= \bar{Y}1 [X1 + Y0 (X0 + C_n)] \\ \bar{C}_{n+z} &= \bar{Y}2 \{X2 + Y1 [X1 + Y0 (X0 + C_n)]\} \end{aligned} \\
 \bar{G} &= G3 + P3 G2 + P3 P2 G1 + P3 P2 P1 G0 \\
 \bar{P} &= P3 P2 P1 P0 \\
 Y &= Y3 (X3 + Y2) (X3 + X2 + Y1) (X3 + X2 + X1 + Y0) \\
 X &= X3 + X2 + X1 + X0
 \end{aligned}$$

## maximum ratings recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

SN54HC182...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

PRODUCT PREVIEWS

5

## PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

TEXAS  
INSTRUMENTS

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# TYPES SN54HC182, SN74HC182 LOOK-AHEAD CARRY GENERATOR

FUNCTION TABLE FOR $\bar{G}$ OUTPUT							
INPUTS							OUTPUT
$\bar{G}_3$	$\bar{G}_2$	$\bar{G}_1$	$\bar{G}_0$	$\bar{P}_3$	$\bar{P}_2$	$\bar{P}_1$	
L	X	X	X	X	X	X	L
X	L	X	X	L	X	X	L
X	X	L	X	L	L	X	L
X	X	X	L	L	L	L	L
All other combinations							H

FUNCTION TABLE FOR $\bar{P}$ OUTPUT				
INPUTS				OUTPUT
$\bar{P}_3$	$\bar{P}_2$	$\bar{P}_1$	$\bar{P}_0$	
L	L	L	L	L
All other combinations				H

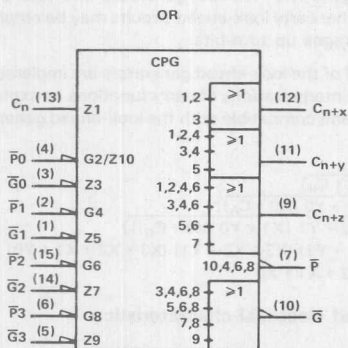
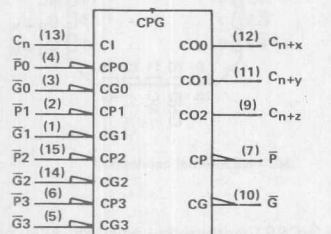
FUNCTION TABLE FOR $C_{n+x}$ OUTPUT			
INPUTS			OUTPUT
$\bar{G}_0$	$\bar{P}_0$	$C_n$	
L	X	X	H
X	L	H	H
All other combinations			L

FUNCTION TABLE $C_{n+y}$ OUTPUT					
INPUTS					OUTPUT
$\bar{G}_1$	$\bar{G}_0$	$\bar{P}_1$	$\bar{P}_0$	$C_n$	
L	X	X	X	X	H
X	L	L	X	X	H
X	X	L	L	H	H
All other combinations					L

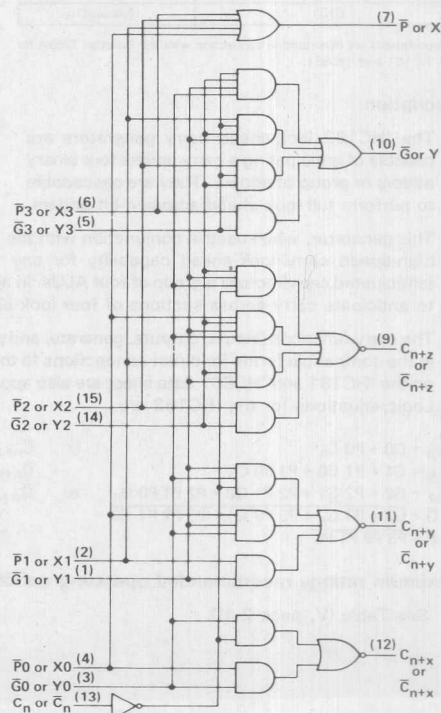
FUNCTION TABLE FOR $C_{n+z}$ OUTPUT							
INPUTS							OUTPUT
$\bar{G}_2$	$\bar{G}_1$	$\bar{G}_0$	$\bar{P}_2$	$\bar{P}_1$	$\bar{P}_0$	$C_n$	
L	X	X	X	X	X	X	H
X	L	X	L	X	X	X	H
X	X	L	L	L	X	X	H
X	X	X	L	L	L	H	H
All other combinations							L

H = High-level, L = Low-level, X = Irrelevant  
Any inputs not shown in a given table are irrelevant with respect to that output.

## logic symbols (alternatives)



## logic diagram (positive logic)



Pin numbers shown are for J and N packages only.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC221, SN74HC221 DUAL MONOSTABLE MULTIVIBRATORS WITH SCHMITT-TRIGGER INPUTS

D2684, DECEMBER 1982 - REVISED MARCH 1984

- Overriding Clear Terminates Output Pulse
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices are monolithic dual multivibrators featuring a negative-transition-triggered input and a positive-transition-triggered input either of which can be used as an inhibit input.

Pulse triggering occurs at a particular voltage level and is not directly related to the transition time of the input pulse. Schmitt-trigger input circuitry for the B input allows jitter-free triggering from inputs with slow transition rates.

Once fired, the outputs are independent of further transitions of the A and B inputs and are a function of the timing components, or the output pulses can be terminated by the overriding clear. Input pulses may be of any duration relative to the output pulse. Output rise and fall times are independent of pulse length.

Pulse duration stability is achieved through internal compensation and is virtually independent of  $V_{CC}$  and temperature. In most applications, pulse stability will be limited only by the accuracy of external timing components.

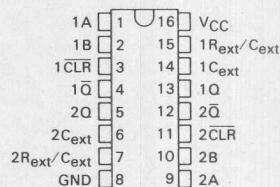
The SN54HC221 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC221 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

FUNCTION TABLE  
(EACH MONOSTABLE)

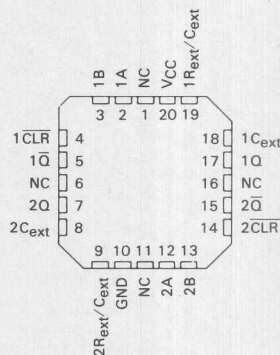
INPUTS			OUTPUTS	
CLEAR	A	B	Q	$\bar{Q}$
L	X	X	L	H
X	H	X	L†	H†
X	X	L	L†	H†
H	L	↑	□	□
H	↓	H	□	□
↑	L	H	□	□

† The second and third lines each indicate the logic levels the outputs will take on after the completion of any pulse already started.

SN54HC221... J PACKAGE  
SN74HC221... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

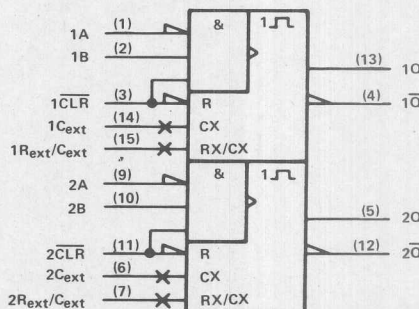


SN54HC221... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



### maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

NOTE: The minimum recommended supply voltage for this device is 3 V.

#### PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

TEXAS  
INSTRUMENTS

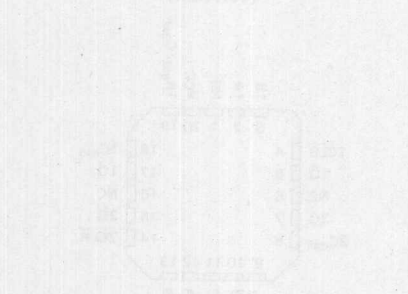
Copyright ©1982 by Texas Instruments Incorporated

# TYPE 5000 DUAL MONOSTABLE MULTIVIBRATOR WITH SCHMITT TRIGGER INPUT

DESCRIPTION: This device is a dual monostable multivibrator with Schmitt trigger input. It is designed to provide a single output pulse of a specified width in response to a trigger input. The output pulse width is determined by a single external resistor and capacitor. The device is capable of operating from a single 5V supply.

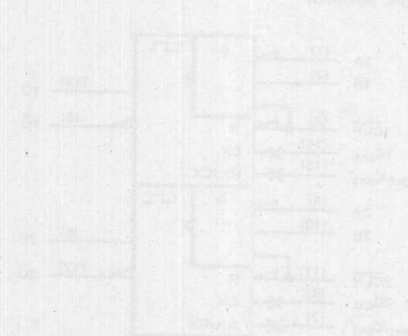


FUNCTION TABLE:  
The output is high for a period of time determined by the external resistor and capacitor. The output is low for the remainder of the cycle.



Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC



Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

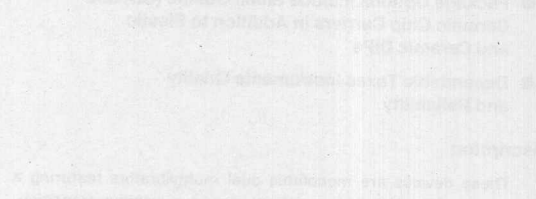
Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

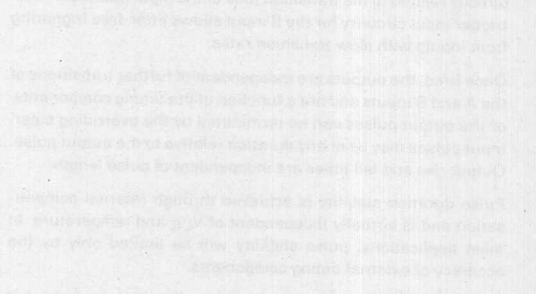
Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

# TYPE 5000 DUAL MONOSTABLE MULTIVIBRATOR WITH SCHMITT TRIGGER INPUT

DESCRIPTION: This device is a dual monostable multivibrator with Schmitt trigger input. It is designed to provide a single output pulse of a specified width in response to a trigger input. The output pulse width is determined by a single external resistor and capacitor. The device is capable of operating from a single 5V supply.



FUNCTION TABLE:  
The output is high for a period of time determined by the external resistor and capacitor. The output is low for the remainder of the cycle.



Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC



Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

Pin 1: GND  
Pin 2: VCC  
Pin 3: TRIGGER  
Pin 4: VCC  
Pin 5: GND  
Pin 6: VCC  
Pin 7: GND  
Pin 8: VCC  
Pin 9: GND  
Pin 10: VCC  
Pin 11: GND  
Pin 12: VCC  
Pin 13: GND  
Pin 14: VCC  
Pin 15: GND  
Pin 16: VCC

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC292, SN54HC294, SN74HC292, SN74HC294 PROGRAMMABLE FREQUENCY DIVIDERS/DIGITAL TIMERS

D2804, MARCH 1984

- Count Divider Chain
- Digitally Programmable from  $2^2$  to  $2^{31}$  for 'HC292 or  $2^{15}$  for 'HC294
- Usable Frequency Range from DC to 30 MHz
- Easily Expandable
- Applications
  - Frequency Division
  - Digital Timing
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These are programmable frequency dividers/digital timers whose count modulo is under digital control of the inputs provided.

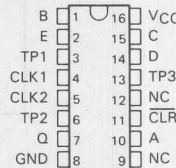
Both types feature an active-low clear input to initialize the state of all flip-flops. To facilitate incoming inspection, test points are provided (TP1, TP2, and TP3 on the 'HC292 and TP on the 'HC294). These test points are not intended to drive system loads. Both types feature two clock inputs; either one may be used for clock gating. (See the function table.)

A brief look at the digital timing capabilities of the 'HC292 will show that with a 1-MHz input frequency, programming for  $2^{10}$  will give a period of 1.024 ms, and  $2^{20}$  will give a period of 1.05 sec,  $2^{26}$  will give a period of 1.12 min, and  $2^{31}$  will give a period of 35.79 min.

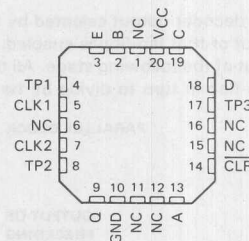
These devices are easily cascadable giving limitless possibilities to timing delays that can be achieved.

The SN54HC292 and SN54HC294 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC292 and SN74HC294 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

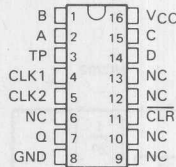
SN54HC292...J PACKAGE  
SN74HC292...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



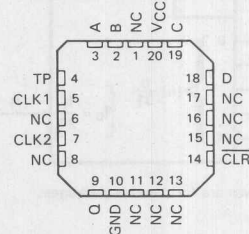
SN54HC292...FH OR FK PACKAGE  
(TOP VIEW)



SN54HC294...J PACKAGE  
SN74HC294...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC294...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### PRODUCT PREVIEW

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# TYPES SN54HC292, SN54HC294, SN74HC292, SN74HC294 PROGRAMMABLE FREQUENCY DIVIDERS/DIGITAL TIMERS

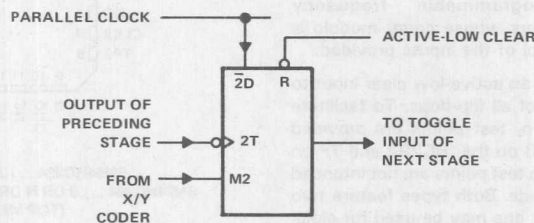
'HC292, 'HC294 FUNCTION TABLE

CLEAR	CLK 1	CLK 2	Q OUTPUT MODE
L	X	X	Cleared to L
H	↑	L	Count
H	L	↑	Count
H	H	X	Inhibit
H	X	H	Inhibit

## operation

The logic diagram shows that the count modulo is controlled by an X/Y decoder connected to the mode-control inputs of several flip-flops. These flip-flops with mode controls each have a "D" input connected to the parallel clock line and a "T" input driven by the preceding stage. The parallel clock frequency is always the input frequency divided by four.

The X/Y decoder output selected by the programming inputs goes low. While a mode control is low, the "D" input of that flip-flop is enabled, and the signal from the parallel clock line ( $f_{in} \div 4$ ) is passed to the "T" input of the following stage. All the other mode controls are high enabling the "T" inputs and causing each flip-flop in turn to divide by two.

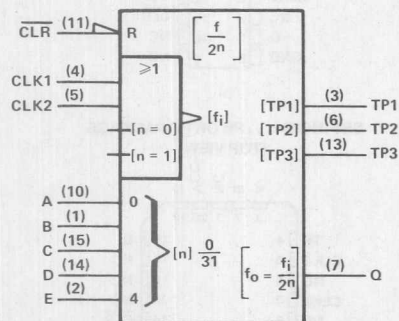


PRODUCT PREVIEWS

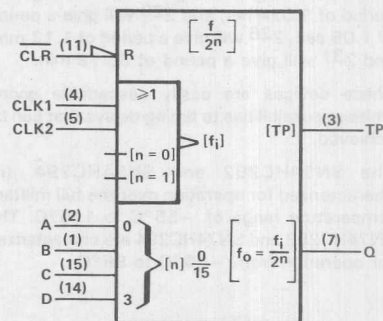
5

## logic symbols

'HC292

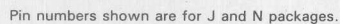


'HC294



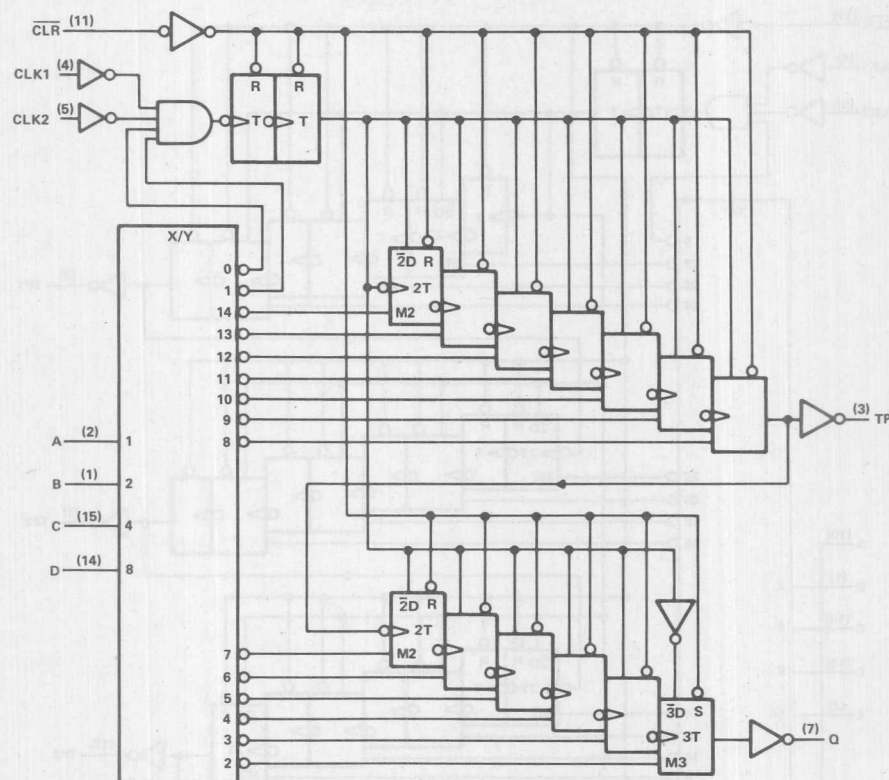
Pin numbers shown are for J and N packages.

## 5 PRODUCT PREVIEWS



**TYPES SN54HC294, SN74HC294**  
**PROGRAMMABLE FREQUENCY DIVIDERS/DIGITAL TIMERS**

'HC294 logic diagram (positive logic)



Pin numbers shown are for J and N packages.



# **TYPES SN54HC292, SN74HC292** **PROGRAMMABLE FREQUENCY DIVIDERS/DIGITAL TIMERS**

HC292 FUNCTION TABLE

PROGRAMMING INPUTS	FREQUENCY DIVISION							
	Q		TP1		TP2		TP3	
	BINARY	DECIMAL	BINARY	DECIMAL	BINARY	DECIMAL	BINARY	DECIMAL
L L L L L	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit
L L L L H	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit
L L L H L	2 <sup>2</sup>	4	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L L L H H	2 <sup>3</sup>	8	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L L H L L	2 <sup>4</sup>	16	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L L H L H	2 <sup>5</sup>	32	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L L H H L	2 <sup>6</sup>	64	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L L H H H	2 <sup>7</sup>	128	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
L H L L L	2 <sup>8</sup>	256	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>2</sup>	4
L H L L H	2 <sup>9</sup>	512	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>2</sup>	4
L H L H L	2 <sup>10</sup>	1,024	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>4</sup>	16
L H L H H	2 <sup>11</sup>	2,048	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>4</sup>	16
L H H L L	2 <sup>12</sup>	4,096	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>6</sup>	64
L H H L H	2 <sup>13</sup>	8,192	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>6</sup>	64
L H H H L	2 <sup>14</sup>	16,384	2 <sup>9</sup>	512	Disabled Low		2 <sup>8</sup>	256
L H H H H	2 <sup>15</sup>	32,768	2 <sup>9</sup>	512	Disabled Low		2 <sup>8</sup>	256
H L L L L	2 <sup>16</sup>	65,536	2 <sup>9</sup>	512	2 <sup>3</sup>	8	2 <sup>10</sup>	1,024
H L L L H	2 <sup>17</sup>	131,072	2 <sup>9</sup>	512	2 <sup>3</sup>	8	2 <sup>10</sup>	1,024
H L L H L	2 <sup>18</sup>	262,144	2 <sup>9</sup>	512	2 <sup>5</sup>	32	2 <sup>12</sup>	4,096
H L L H H	2 <sup>19</sup>	524,288	2 <sup>9</sup>	512	2 <sup>5</sup>	32	2 <sup>12</sup>	4,096
H L H L L	2 <sup>20</sup>	1,048,576	2 <sup>9</sup>	512	2 <sup>7</sup>	128	2 <sup>14</sup>	16,384
H L H L H	2 <sup>21</sup>	2,097,152	2 <sup>9</sup>	512	2 <sup>7</sup>	128	2 <sup>14</sup>	16,384
H L H H L	2 <sup>22</sup>	4,194,304	Disabled Low		2 <sup>9</sup>	512	2 <sup>16</sup>	65,536
H L H H H	2 <sup>23</sup>	8,388,608	Disabled Low		2 <sup>9</sup>	512	2 <sup>16</sup>	65,536
H H L L L	2 <sup>24</sup>	16,777,216	2 <sup>3</sup>	8	2 <sup>11</sup>	2,048	2 <sup>18</sup>	262,144
H H L L H	2 <sup>25</sup>	33,554,432	2 <sup>3</sup>	8	2 <sup>11</sup>	2,048	2 <sup>18</sup>	262,144
H H L H L	2 <sup>26</sup>	67,108,864	2 <sup>5</sup>	32	2 <sup>13</sup>	8,192	2 <sup>20</sup>	1,048,576
H H L H H	2 <sup>27</sup>	134,217,728	2 <sup>5</sup>	32	2 <sup>13</sup>	8,192	2 <sup>20</sup>	1,048,576
H H H L L	2 <sup>28</sup>	268,435,456	2 <sup>7</sup>	128	2 <sup>15</sup>	32,768	2 <sup>22</sup>	4,194,304
H H H L H	2 <sup>29</sup>	536,870,912	2 <sup>7</sup>	128	2 <sup>15</sup>	32,768	2 <sup>22</sup>	4,194,304
H H H H L	2 <sup>30</sup>	1,073,741,824	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216
H H H H H	2 <sup>31</sup>	2,147,483,648	2 <sup>9</sup>	512	2 <sup>17</sup>	131,072	2 <sup>24</sup>	16,777,216

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

PRODUCT PREVIEWS

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**TYPES SN54HC294, SN74HC294**  
**PROGRAMMABLE FREQUENCY DIVIDERS/DIGITAL TIMERS**

**\*HC294 FUNCTION TABLE**

PROGRAMMING INPUTS				FREQUENCY DIVISION			
				Q		TP	
D	C	B	A	BINARY	DECIMAL	BINARY	DECIMAL
L	L	L	L	Inhibit	Inhibit	Inhibit	Inhibit
L	L	L	H	Inhibit	Inhibit	Inhibit	Inhibit
L	L	H	L	2 <sup>2</sup>	4	2 <sup>9</sup>	512
L	L	H	H	2 <sup>3</sup>	8	2 <sup>9</sup>	512
L	H	L	L	2 <sup>4</sup>	16	2 <sup>9</sup>	512
L	H	L	H	2 <sup>5</sup>	32	2 <sup>9</sup>	512
L	H	H	L	2 <sup>6</sup>	64	2 <sup>9</sup>	512
L	H	H	H	2 <sup>7</sup>	128	Disabled Low	
H	L	L	L	2 <sup>8</sup>	256	2 <sup>2</sup>	4
H	L	L	H	2 <sup>9</sup>	512	2 <sup>3</sup>	8
H	L	H	L	2 <sup>10</sup>	1,024	2 <sup>4</sup>	16
H	L	H	H	2 <sup>11</sup>	2,048	2 <sup>5</sup>	32
H	H	L	L	2 <sup>12</sup>	4,096	2 <sup>6</sup>	64
H	H	L	H	2 <sup>13</sup>	8,192	2 <sup>7</sup>	128
H	H	H	L	2 <sup>14</sup>	16,384	2 <sup>8</sup>	256
H	H	H	H	2 <sup>15</sup>	32,768	2 <sup>9</sup>	512

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC381, SN54HC382 SN74HC381, SN74HC382 ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

D2804, MARCH 1984

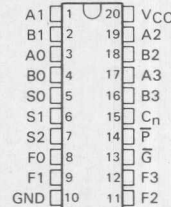
- Fully Parallel 4-Bit ALUs in 20-Pin Package
- Ideally Suited for High-Density Economical Processors
- 'HC381 Features  $\bar{G}$  and  $\bar{P}$  Outputs for Look-Ahead Carry Cascading
- 'HC382 Features Ripple Carry ( $C_{n+4}$ ) and Overflow (OVR) Outputs
- Arithmetic and Logic Operations Selected Specifically to Simplify System Implementation:
  - A Minus B
  - B Minus A
  - A Plus B
  - and Five Other Functions
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### **description**

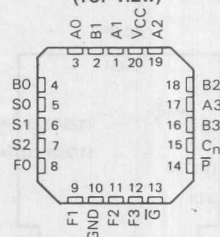
The 'HC381 and 'HC382 are arithmetic logic units (ALUs)/function generators that perform eight binary arithmetic/logic operations on two 4-bit words as shown in the function table. The Exclusive-OR, AND, or OR function of the two Boolean variables is provided without the use of external circuitry. Also the F outputs can be cleared (low) or preset (high) as desired. The 'HC381 provides two cascade outputs ( $\bar{P}$  and  $\bar{G}$ ) for expansion utilizing SN54HC182/SN74HC182 look-ahead carry generators. The 'HC382 provides a  $C_{n+4}$  output to ripple the carry to the  $C_n$  input of the next stage. The 'HC382 detects and indicates two's complement overflow condition via the OVR output. The overflow output is logically equivalent to  $C_{n+3} \oplus C_{n+4}$ . When the 'HC382 is cascaded to handle word lengths longer than four bits in length, only the most significant overflow (OVR) output is used.

The SN54HC381 and SN54HC382 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC381 and SN74HC382 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

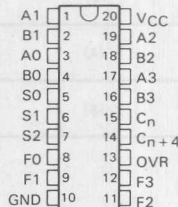
**SN54HC381 ... J PACKAGE  
SN74HC381 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



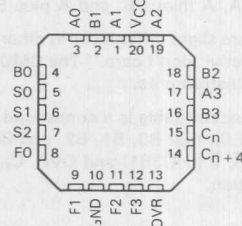
**SN54HC381 ... FH OR FK PACKAGE  
(TOP VIEW)**



**SN54HC382 ... J PACKAGE  
SN74HC382 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)**



**SN54HC382 ... FH OR FK PACKAGE  
(TOP VIEW)**



### **PRODUCT PREVIEW**

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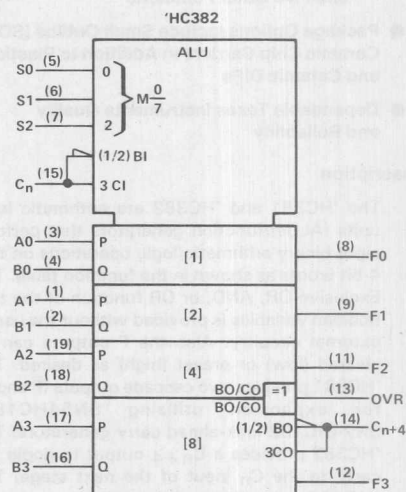
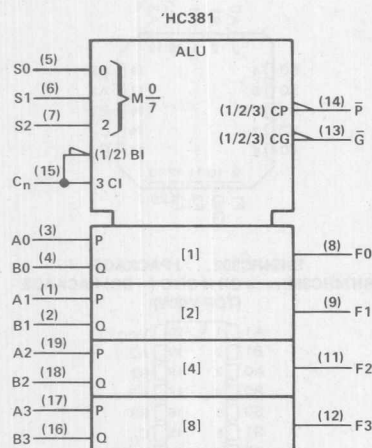
**TYPES SN54HC381, SN54HC382  
SN74HC381, SN74HC382  
ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

FUNCTION TABLE

SELECTION			ARITHMETIC/LOGIC
S2	S1	S0	OPERATION
L	L	L	CLEAR
L	L	H	B MINUS A
L	H	L	A MINUS B
L	H	H	A PLUS B
H	L	L	$A \oplus B$
H	L	H	$A + B$
H	H	L	AB
H	H	H	PRESET

H = high level, L = low level

logic symbols



function table

Certain differences exist in the  $\bar{G}$ ,  $\bar{P}$  ('HC381) and OVR,  $C_{n+4}$  ('HC382) function table compared with similar parts from other technologies and other vendors. No differences exist in the arithmetic modes (B minus A, A minus B, and A plus B), where these outputs perform valuable cascade functions.

There are slight differences in other modes (CLEAR,  $A + B$ ,  $A \oplus B$ , AB, and PRESET) where these outputs are strictly "don't care." The CMOS implementation will be the same as for the LSTTL counterparts from Texas Instruments.

This function table is a condensed version and assumes for  $A_n$  that A0, A1, A2, and A3 inputs all agree and for  $B_n$  that B0, B1, B2, and B3 inputs all agree. This table is intended to point out the response of these  $\bar{G}$ ,  $\bar{P}$  ('HC381) and OVR,  $C_{n+4}$  ('HC382) outputs in all modes of operation to facilitate incoming inspection.

**TYPES SN54HC381, SN54HC382  
SN74HC381, SN74HC382  
ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

FUNCTION TABLE

ARITHMETIC/LOGIC OPERATION	INPUTS						OUTPUTS				('HC381)		('HC382)	
	S2	S1	S0	C <sub>n</sub>	A <sub>n</sub>	B <sub>n</sub>	F3	F2	F1	F0	G	P	OVR	C <sub>n+4</sub>
Clear	L	L	L	X	X	X	L	L	L	L	H	H	L	L
B MINUS A	L	L	H	L	L	L	H	H	H	H	H	L	L	L
				L	L	H	H	H	H	L	L	H	L	H
				L	H	L	L	L	L	L	H	H	L	L
				L	H	H	H	H	H	H	H	L	L	L
				H	L	L	L	L	L	L	H	L	L	H
				H	L	H	H	H	H	H	L	H	L	H
				H	H	L	L	L	L	H	H	H	L	L
				H	H	H	L	L	L	L	H	L	L	H
A MINUS B	L	H	L	L	L	L	H	H	H	H	H	L	L	L
				L	L	H	L	L	L	L	H	H	L	L
				L	H	L	H	H	H	L	L	H	L	H
				L	H	H	H	H	H	H	H	L	L	L
				H	L	L	L	L	L	L	H	L	L	H
				H	L	H	L	L	L	H	H	H	L	L
				H	H	L	H	H	H	H	L	H	L	H
				H	H	H	L	L	L	L	H	L	L	H
A PLUS B	L	H	H	L	L	L	L	L	L	L	H	H	L	L
				L	L	H	H	H	H	H	H	L	L	L
				L	H	L	H	H	H	L	L	H	L	H
				L	H	H	H	H	H	L	L	H	L	L
				H	L	L	L	L	L	L	H	L	L	H
				H	L	H	L	L	L	L	H	L	L	H
				H	H	L	L	L	L	L	H	L	L	H
				H	H	H	H	H	H	H	L	H	L	H
$A \oplus B$	H	L	L	X	L	L	L	L	L	L	H	H	L	L
				L	L	H	H	H	H	H	H	L	L	L
				H	L	H	H	H	H	H	H	L	L	H
				L	H	L	H	H	H	H	H	L	L	L
				H	H	L	H	H	H	H	H	L	L	H
				X	H	H	L	L	L	L	H	H	L	L
				L	L	L	L	L	L	L	H	H	L	L
				L	L	H	H	H	H	H	H	L	L	L
A + B	H	L	H	X	L	L	L	L	L	L	H	H	L	L
				L	L	H	H	H	H	H	H	L	L	L
				L	H	L	H	H	H	H	H	L	L	L
				L	H	H	H	H	H	H	H	L	L	L
				H	L	L	L	L	L	L	H	L	L	L
				H	L	H	L	L	L	L	H	L	L	L
				H	H	L	L	L	L	L	H	L	L	L
				H	H	H	H	H	H	H	H	L	L	L
AB	H	H	L	X	L	L	L	L	L	L	H	H	L	L
				X	L	H	L	L	L	L	H	H	L	L
				X	H	L	L	L	L	L	H	H	L	L
				L	H	H	H	H	H	H	H	L	L	L
				H	H	L	L	L	L	L	H	L	L	L
				H	H	H	H	H	H	H	H	L	L	L
				L	X	X	H	H	H	H	H	L	L	L
				H	X	X	H	H	H	H	H	L	L	L
PRESET	H	H	H	L	X	X	H	H	H	H	H	L	L	L
				H	X	X	H	H	H	H	H	L	L	L

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

**TYPES SN54HC381, SN54HC382  
SN74HC381, SN74HC382  
ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

'HC381 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC381		SN74HC381		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	C <sub>n</sub>	Any F	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	A <sub>i</sub> or B <sub>i</sub>	F <sub>i</sub>	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	Any A or B	$\bar{G}$ or $\bar{P}$	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	S0, S1, or S2	F <sub>i</sub>	2 V		52						ns
			4.5 V		17						
			6 V		14						
t <sub>pd</sub>	S0, S1, or S2	$\bar{G}$ or $\bar{P}$	2 V		50						ns
			4.5 V		17						
			6 V		14						

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	100 pF typ
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'HC382 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC382		SN74HC382		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	C <sub>n</sub>	Any F	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	C <sub>n</sub>	OVR	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	C <sub>n</sub>	C <sub>n</sub> + 4	2 V		33						ns
			4.5 V		11						
			6 V		10						
t <sub>pd</sub>	A <sub>i</sub> or B <sub>i</sub>	F <sub>i</sub>	2 V		36						ns
			4.5 V		12						
			6 V		10						
t <sub>pd</sub>	Any A or B	C <sub>n</sub> + 4	2 V		39						ns
			4.5 V		13						
			6 V		11						
t <sub>pd</sub>	Any A or B	OVR	2 V		42						ns
			4.5 V		14						
			6 V		12						
t <sub>pd</sub>	S0, S1, or S2	F <sub>i</sub>	2 V		52						ns
			4.5 V		17						
			6 V		14						
t <sub>pd</sub>	S0, S1, or S2	C <sub>n</sub> + 4 or OVR	2 V		60						ns
			4.5 V		20						
			6 V		17						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



# HIGH-SPEED CMOS LOGIC

# TYPES SN54HC423, SN74HC423 DUAL RETRIGGERABLE MONOSTABLE MULTIVIBRATORS

D2684, DECEMBER 1982 - REVISED MARCH 1984

- Retriggerable for Very Long Output Pulses, Up to 100% Duty Cycle
- Overriding Clear Terminates Output Pulse
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## description

These dc-triggered multivibrators feature output-pulse-duration control by two methods. The basic pulse duration is programmed by selection of external resistance and capacitance values. Once triggered, the basic pulse duration may be extended by retriggering the gated low-level-active (A) or high-level-active (B) inputs, or be reduced by use of the overriding clear. Figure 1 illustrates pulse control by retriggering and early clear.

The B input is a Schmitt trigger enabling jitter-free triggering from input signals with slow transition rates.

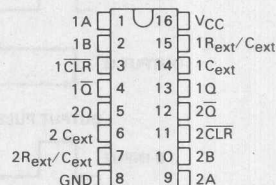
The SN54HC423 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC423 is characterized for operation from -40°C to 85°C.

FUNCTION TABLE

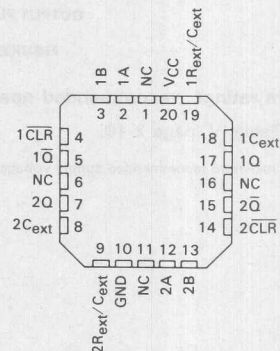
INPUTS			OUTPUTS	
CLEAR	A	B	Q	$\bar{Q}$
L	X	X	L	H
X	H	X	L*	H*
X	X	L	L*	H*
H	L	↑		
H	↓	H		

\*These are the logic levels the outputs will take on after the completion of any pulse already started.

SN54HC423 . . . J PACKAGE  
SN74HC423 . . . J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

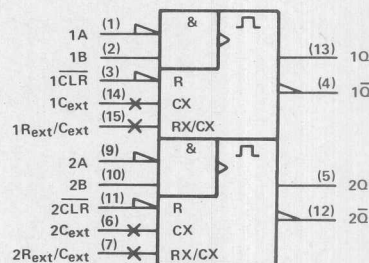


SN54HC423 . . . FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

## logic symbol



Pin numbers shown are for J and N packages.

5 PRODUCT PREVIEWS

## PRODUCT PREVIEW

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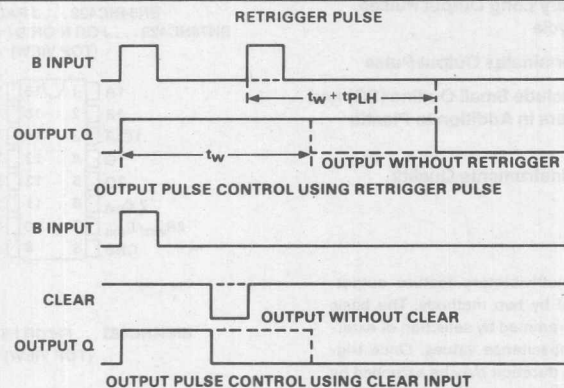


FIGURE 1—TYPICAL INPUT/OUTPUT PULSES

maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

NOTE: The minimum recommended supply voltage for this device is 3 V.

STATUS		STATUS	
Q	A	Q	A
0	0	0	0
0	1	0	1
1	0	1	0
1	1	1	1

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC592, SN54HC593, SN74HC592, SN74HC593 8-BIT BINARY COUNTERS WITH INPUT REGISTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Parallel Register Inputs ('HC592)
- Parallel 3-State I/O: Register Inputs/Counter Outputs ('HC593)
- Counter Has Direct Overriding Load and Clear
- High-Current Outputs Can Drive up to 15 LSTTL Loads ('HC593)
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

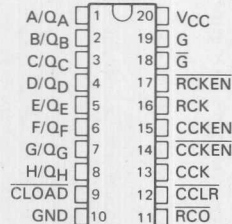
### description

The 'HC592 consists of a parallel input, 8-bit storage register feeding an 8-bit binary counter. Both the register and the counter have individual positive-edge-triggered clocks. In addition, the counter has direct load and clear functions. Expansion is easily accomplished by connecting RCO of the first stage to the count enable of the second stage, etc.

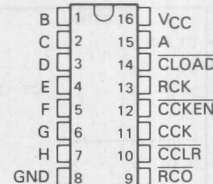
The 'HC593 has all the features of the 'HC592 plus 3-state I/O, which provides parallel counter outputs.

The SN54HC592 and SN54HC593 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC592 and SN74HC593 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

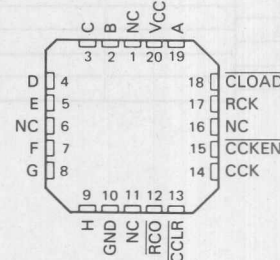
SN54HC593... J PACKAGE  
SN74HC593... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC592... J PACKAGE  
SN74HC592... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

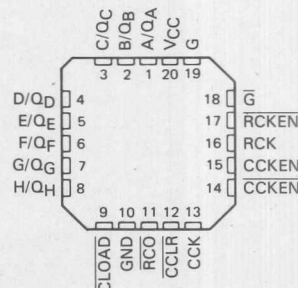


SN54HC592... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

SN54HC593... FH OR FK PACKAGE  
(TOP VIEW)



### PRODUCT PREVIEW

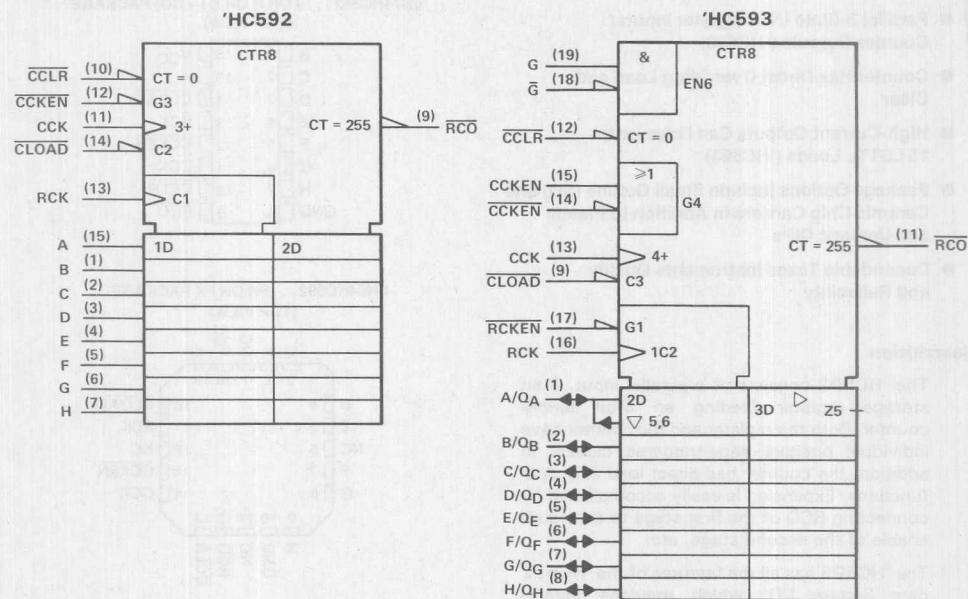
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# **TYPES SN54HC592, SN54HC593, SN74HC592, SN74HC593** **8-BIT BINARY COUNTERS WITH INPUT REGISTERS**

## **logic symbols**



Pin numbers shown are for J and N packages.

**5**

## **maximum ratings, recommended operating conditions, and electrical characteristics**

'HC592: See Table IV, page 2-10.

'HC593: See Table III, page 2-8.

**TYPES SN54HC592, SN54HC593, SN74HC592, SN74HC593**  
**8-BIT BINARY COUNTERS WITH INPUT REGISTERS**

**timing requirements over recommended operating free-air temperature range (unless otherwise noted)**

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC'		SN74HC'		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub> Clock frequency, CCK or RCK		2 V	0	3.3					MHz
		4.5 V	0	17					
		6 V	0	19					
t <sub>w</sub> Pulse duration	CCK or RCK high or low	2 V	150						ns
		4.5 V	30						
		6 V	26						
	$\overline{\text{CCLR}}$ low	2 V	125						ns
		4.5 V	25						
		6 V	21						
	$\overline{\text{CLOAD}}$ low	2 V	125						ns
		4.5 V	25						
		6 V	21						
t <sub>su</sub> Setup time	$\overline{\text{CCKEN}}$ low before CCK	2 V	125						ns
		4.5 V	25						
		6 V	21						
	$\overline{\text{CCLR}}$ high (inactive) before CLK ↑	2 V	125						ns
		4.5 V	25						
		6 V	21						
	RCK ↑ before CCK ↑ (see Note 1)	2 V	200						ns
		4.5 V	40						
		6 V	34						
	Data A thru H before RCK ↑	2 V	125						ns
		4.5 V	25						
		6 V	21						
t <sub>h</sub> Hold time		2 V	5						ns
		4.5 V	5						
		6 V	5						

NOTE 1: The RCK  $\uparrow$  to CCK  $\uparrow$  setup time ensures that the counter will see stable data from the register outputs.

**'HC592 switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 2)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC592		SN74HC592		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$	CCK or RCK		2 V	3.3	8						MHz
			4.5 V	17	35						
			6 V	19	40						
$t_{\text{pd}}$	CCK $\uparrow$	$\overline{\text{RCO}}$	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{\text{pd}}$	$\overline{\text{CLOAD}}$ $\downarrow$	$\overline{\text{RCO}}$	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{\text{PHL}}$	$\overline{\text{CCLR}}$ $\downarrow$	$\overline{\text{RCO}}$	2 V		85						ns
			4.5 V		28						
			6 V		24						
$t_{\text{pd}}$	RCK $\uparrow$	$\overline{\text{RCO}}$	2 V		105						ns
			4.5 V		35						
			6 V		30						

NOTE 2: For load circuits and voltage waveforms, see page 1-14.

**TYPES SN54HC593, SN74HC593**  
**8-BIT BINARY COUNTERS WITH INPUT REGISTERS**

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC593		SN74HC593		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\max}$	CCK or RCK		2 V	3.3	8						MHz
			4.5 V	17	35						
			6 V	19	40						
$t_{pd}$	CCK $\uparrow$	Q	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{pd}$	CCK $\uparrow$	$\overline{RCO}$	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{pd}$	$\overline{CLOAD} \downarrow$	Q	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{pd}$	$\overline{CLOAD} \downarrow$	$\overline{RCO}$	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{pd}$	RCK $\uparrow$	$\overline{RCO}$	2 V		105						ns
			4.5 V		35						
			6 V		30						
$t_{PHL}$	$\overline{CCLR} \downarrow$	Q	2 V		90						ns
			4.5 V		30						
			6 V		26						
$t_{PHL}$	$\overline{CCLR} \downarrow$	$\overline{RCO}$	2 V		90						ns
			4.5 V		30						
			6 V		26						
$t_{en}$	G $\uparrow$	Q	2 V		66						ns
			4.5 V		22						
			6 V		19						
$t_{en}$	$\overline{G} \downarrow$	Q	2 V		75						ns
			4.5 V		25						
			6 V		21						
$t_{dis}$	G $\downarrow$	Q	2 V		60						ns
			4.5 V		20						
			6 V		17						
$t_{dis}$	$\overline{G} \uparrow$	Q	2 V		60						ns
			4.5 V		20						
			6 V		17						
$t_t$			2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC594, SN74HC594 8-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8-Bit Serial-In, Parallel-Out Shift Registers With Storage
- Independent Direct-Overriding Clears On Shift and Storage Registers
- Independent Clocks for Both Shift and Storage Registers
- High-Current Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

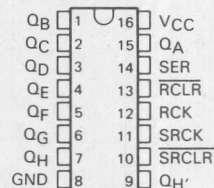
These devices each contain an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. Separate clocks and direct-overriding clears are provided on both the shift and storage registers. A serial output (QH') is provided for cascading purposes.

Both the shift register and storage register clocks are positive-edge triggered. If the user wishes to connect both clocks together, the shift register will always be one clock pulse ahead of the storage register.

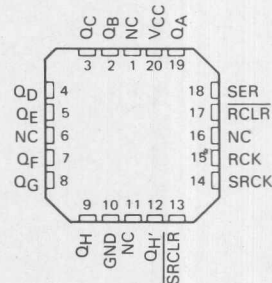
The parallel outputs (QA thru QH) have high-current capability; output QH' is a standard output.

The SN54HC594 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC594 is characterized for operation from -40°C to 85°C.

SN54HC594 ... J PACKAGE  
SN74HC594 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

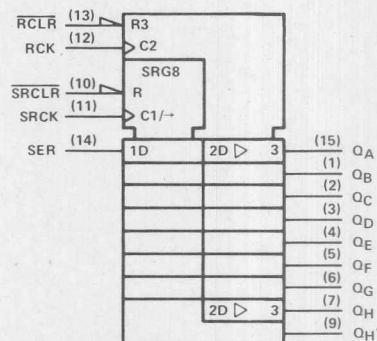


SN54HC594 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, over recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

#### PRODUCT PREVIEW

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PRODUCT PREVIEWS

5

# 5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

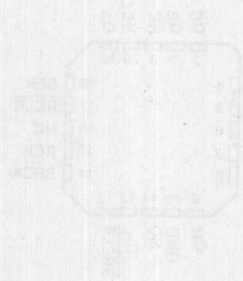
5-BIT SHIFT  
REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

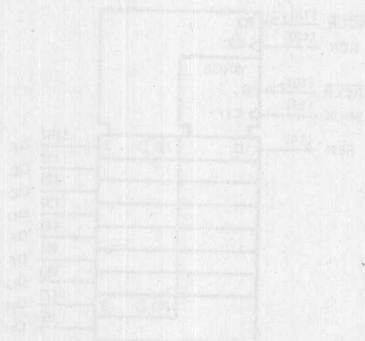
5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS



5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS



5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS



5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

5-BIT SHIFT REGISTERS WITH OUTPUT REGISTERS

- 8-Bit Serial-In, Parallel-Out Shift Registers with Storage
- High-Current 3-State Outputs Can Drive Up to 15 LSTTL Loads
- Shift Register Has Direct Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

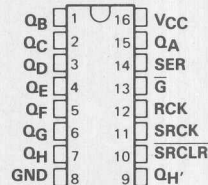
### description

These devices each contain an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. The storage register has parallel 3-state outputs. Separate clocks are provided for both the shift register and the storage register. The shift register has a direct-overriding clear, serial input, and serial output pins for cascading.

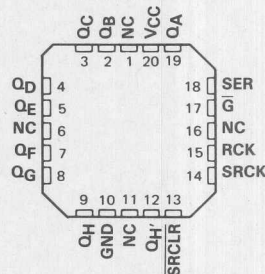
Both the shift register and storage register clocks are positive-edge triggered. If the user wishes to connect both clocks together, the shift register state will always be one clock pulse ahead of the storage register.

The SN54HC595 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC595 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC595... J PACKAGE  
SN74HC595... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

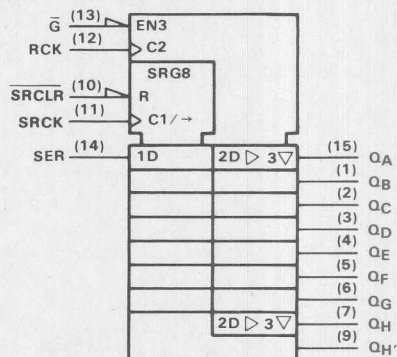


SN54HC595... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

### maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

### PRODUCT PREVIEW

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# HIGH-SPEED CMOS LOGIC

## 8-BIT SHIFTER WITH 3-STATE OUTPUT REGISTER

MODEL 74HC164, 74VHC164, 74VHC164-1

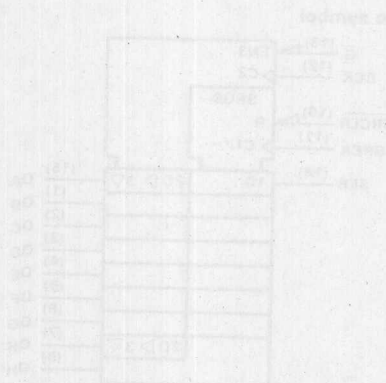
PACKAGE: 16-PIN DIP, 16-PIN SOIC, 16-PIN TSSOP, 16-PIN VSSOP, 16-PIN WSOIC, 16-PIN WSOIC-16



PACKAGE: 16-PIN DIP, 16-PIN SOIC, 16-PIN TSSOP, 16-PIN VSSOP, 16-PIN WSOIC, 16-PIN WSOIC-16



PACKAGE: 16-PIN DIP, 16-PIN SOIC, 16-PIN TSSOP, 16-PIN VSSOP, 16-PIN WSOIC, 16-PIN WSOIC-16



PACKAGE: 16-PIN DIP, 16-PIN SOIC, 16-PIN TSSOP, 16-PIN VSSOP, 16-PIN WSOIC, 16-PIN WSOIC-16

MAXIMUM RATING: Absolute maximum ratings are shown in the table below. Stresses above these ratings may cause permanent damage to the device.

See Table 1 for more details.

TABLE 1. MAXIMUM RATINGS

The maximum ratings are shown in the table below. Stresses above these ratings may cause permanent damage to the device.



PRODUCT PREVIEW



## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC597, SN54HC598, SN74HC597, SN74HC598 8-BIT SHIFT REGISTERS WITH INPUT LATCHES

D2684, DECEMBER 1982—REVISED MARCH 1984

- 8-Bit Parallel Storage Register Inputs ('HC597)
- Parallel 3-State I/O; Storage Register Inputs, High-Current Shift Register Outputs Can Drive up to LSTTL Loads ('HC598)
- Shift Register Has Direct Overriding Load and Clear
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

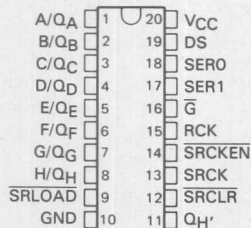
### description

The 'HC597 consists of an 8-bit storage latch feeding a parallel-in, serial-out 8-bit shift register. Both the storage register and shift register have positive edge-triggered clocks. The shift register also has direct load (from storage) and clear inputs.

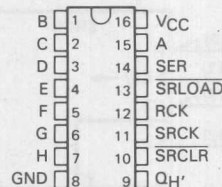
The 'HC598 has all the features of the 'HC597 plus 3-state I/O ports that provide parallel shift register outputs. The 'HC598 also has multiplexed serial data inputs.

The SN54HC597 and SN54HC598 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC597 and SN74HC598 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

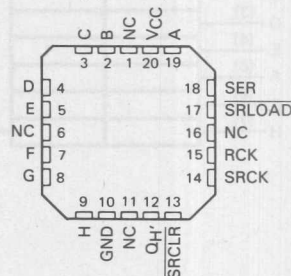
SN54HC598... J PACKAGE  
SN74HC598... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC597... J PACKAGE  
SN74HC597... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

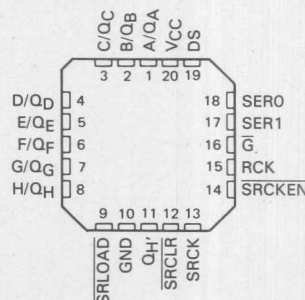


SN54HC597... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

SN54HC598... FH OR FK PACKAGE  
(TOP VIEW)



### PRODUCT PREVIEW

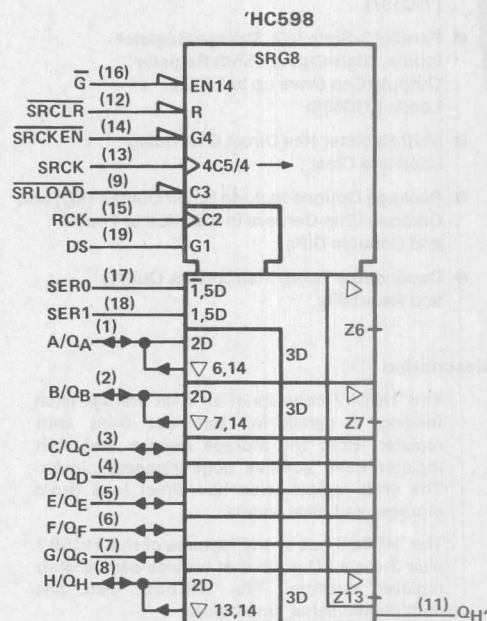
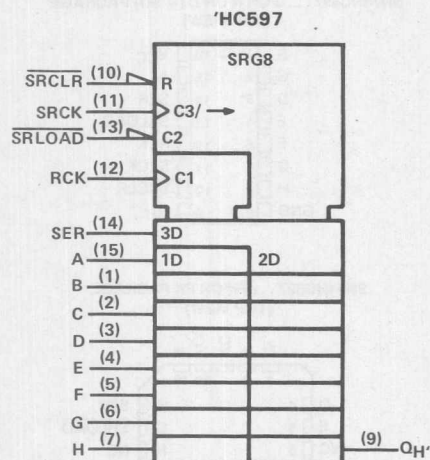
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# **TYPES SN54HC597, SN54HC598, SN74HC597, SN74HC598** **8-BIT SHIFT REGISTERS WITH INPUT LATCHES**

logic symbols



PRODUCT PREVIEWS

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Pin numbers shown are for J and N packages.

**maximum ratings, recommended operating conditions, and electrical characteristics**

'HC597: See Table IV, page 2-10.

'HC598: See Table III, page 2-8.



**TYPES SN54HC597, SN54HC598, SN74HC597, SN74HC598**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

		V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC'		SN74HC'		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
f <sub>clock</sub>	Clock frequency, RCK or SRCK	2 V	0	5					MHz
		4.5 V	0	25					
		6 V	0	29					
t <sub>w</sub>	Pulse duration	RCK or SRCK high or low	2 V	100					ns
			4.5 V	20					
			6 V	17					
	SRCLR low or SRLOAD low		2 V	100					
			4.5 V	20					
			6 V	17					
t <sub>su</sub>	Setup time	SRCKEN low or SRCLR high (inactive) before SRCK ↑	2 V	100					ns
			4.5 V	20					
			6 V	17					
	RCK ↑ before SRCK ↑ (see Note 1)		2 V	200					
			4.5 V	40					
			6 V	34					
	SER before SRCK ↑ or A thru H before RCK ↑		2 V	100					
			4.5 V	20					
			6 V	17					
t <sub>h</sub>	Hold time		2 V	0					ns
			4.5 V	0					
			6 V	0					

NOTE 1: The RCK ↑ before SRCK ↑ setup time ensures that the shift register will see stable data coming from the input register.

PRODUCT PREVIEWS

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**HC597 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 2)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC597		SN74HC597		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$f_{\text{max}}$	RCK or SRCK		2 V		5	8					MHz
			4.5 V		25	35					
			6 V		29	40					
$t_{pd}$	SRCK $\uparrow$	$Q_H'$	2 V			75					ns
			4.5 V			25					
			6 V			21					
$t_{pd}$	$\overline{\text{SRLOAD}} \downarrow$	$Q_H'$	2 V			75					ns
			4.5 V			25					
			6 V			21					
$t_{PHL}$	$\overline{\text{SRCLR}} \downarrow$	$Q_H'$	2 V			60					ns
			4.5 V			20					
			6 V			17					
$t_{pd}$	RCK $\uparrow$	$Q_H'$	2 V			60					ns
			4.5 V			20					
			6 V			17					

NOTE 2: For load circuits and voltage waveforms, see page 1-14.

**TYPES SN54HC598, SN74HC598**  
**8-BIT SHIFT REGISTERS WITH INPUT LATCHES**

'HC598 switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC598		SN74HC598		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
f <sub>max</sub>	RCK or SRCK		2 V		5	8					MHz
			4.5 V		25	35					
			6 V		29	40					
t <sub>pd</sub>	SRCK ↑	Q <sub>H</sub> '	2 V			75					ns
			4.5 V			25					
			6 V			21					
t <sub>pd</sub>	SRLOAD ↓	Q <sub>H</sub> '	2 V			75					ns
			4.5 V			25					
			6 V			21					
t <sub>PHL</sub>	SRCLR ↓	Q <sub>H</sub> '	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>pd</sub>	RCK ↑	Q <sub>H</sub> '	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>pd</sub>	SRCK ↑	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>pd</sub>	SRLOAD ↓	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			60					ns
			4.5 V			20					
			6 V			17					
t <sub>PHL</sub>	SRCLR ↓	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			75					ns
			4.5 V			25					
			6 V			21					
t <sub>en</sub>	G ↓	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			66					ns
			4.5 V			22					
			6 V			19					
t <sub>dis</sub>	G ↑	Q <sub>A</sub> thru Q <sub>H</sub>	2 V			60					ns
			4.5 V			20					
			6 V			17					

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

5 PRODUCT PREVIEWS



# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC630, SN74HC630 16-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

D2804, MARCH 1984

- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Detects and Corrects Single-Bit Errors
- Detects and Flags Dual-Bit Errors
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC630 device is a 16-bit parallel error detection and correction circuit (EDAC) in a 28-pin, 600-mil package. It uses a modified Hamming code to generate a 6-bit check word from a 16-bit data word. This check word is stored along with the data word during the memory write cycle. During the memory read cycle, the 22-bit words from memory are processed by the EDAC to determine if errors have occurred in memory.

Single-bit errors in the 16-bit data word are flagged and corrected.

Single-bit errors in the 6-bit check word are flagged, and the CPU sends the EDAC through the correction cycle even though the 16-bit word is not in error. The correction cycle will simply pass along the original 16-bit word in this case and produce error syndrome bits to pinpoint the error-generating location.

Dual-bit errors are flagged but not corrected. These dual errors may occur in any two bits of the 22-bit word from memory (two errors in the 16-bit data word, two errors in the 6-bit check word, or one error in each word).

The gross-error condition of all lows or all highs from memory will be detected. Otherwise, errors in three or more bits of the 22-bit word are beyond the capabilities of these devices to detect.

The SN54HC630 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC630 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC630 . . . J PACKAGE  
SN74HC630 . . . J OR N PACKAGE

(TOP VIEW)

DEF	1	28	VCC
DB0	2	27	SEF
DB1	3	26	S1
DB2	4	25	S0
DB3	5	24	CB0
DB4	6	23	CB1
DB5	7	22	CB2
DB6	8	21	CB3
DB7	9	20	CB4
DB8	10	19	CB5
DB9	11	18	DB15
DB10	12	17	DB14
DB11	13	16	DB13
GND	14	15	DB12

CONTROL FUNCTION TABLE

MEMORY CYCLE	CONTROL		EDAC FUNCTION	DATA I/O	CHECK WORD I/O	ERROR FLAGS	
	S1	S0				SEF	DEF
WRITE	L	L	Generate Check Word	Input Data	Output Check Word	L	L
READ	L	H	Read Data & Check Word	Input Data	Input Check Word	L	L
READ	H	H	Latch & Flag Errors	Latch Data	Latch Check Word	Enabled	
READ	H	L	Correct Data Word & Generate Syndrome Bits	Output Corrected Data	Output Syndrome Bits	Enabled	

### PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

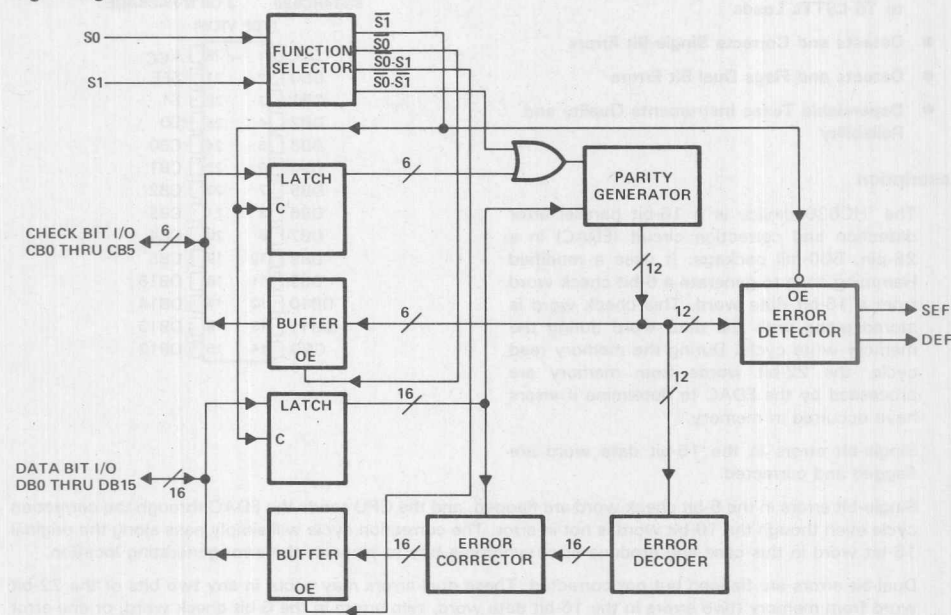
TEXAS  
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# TYPES SN54HC630, SN74HC630 16-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

logic diagram



ERROR FUNCTION TABLE

TOTAL NUMBER OF ERRORS		ERROR FLAGS		DATE CORRECTION
16-BIT DATA	6-BIT CHECK WORD	SEF	DEF	
0	0	L	L	Not Applicable
1	0	H	L	Correction
0	1	H	L	Correction
1	1	H	H	Interrupt
2	0	H	H	Interrupt
0	2	H	H	Interrupt

In order to be able to determine whether the data from the memory is acceptable to use as presented to the bus, the EDAC must be strobed to enable the error flags and the flags will have to be tested for the zero condition.

The first case in the error function table represents the normal, no-error condition. The CPU sees lows on both flags. The next two cases of single-bit errors require data correction. Although the EDAC can discern the single check bit error and ignore it, the error flags are identical to the single error in the 16-bit data word. The CPU will ask for data correction in both cases. An interrupt condition to the CPU results in each of the last three cases, where dual errors occur.



## TYPES SN54HC630, SN74HC630

### 16-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

#### error detection and correction details

During a memory write cycle, six check bits (CB0-CB5) are generated by eight-input parity generators using the data bits as defined below. During a memory read cycle, the 6-bit check word is retrieved along with the actual data.

CHECK WORD BIT	16-BIT DATA WORD															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CB0	X	X		X	X				X	X	X			X		
CB1	X		X	X		X	X		X			X			X	
CB2		X	X		X	X		X		X			X			X
CB3	X	X	X				X	X			X	X	X			
CB4				X	X	X	X	X						X	X	X
CB5									X	X	X	X	X	X	X	X

The six check bits are parity bits derived from the matrix of data bits as indicated by "x" for each bit.

Error detection is accomplished as the 6-bit check word and the 16-bit data word from memory are applied to internal parity generators/checkers. If the parity of all six groupings of data and check bits are correct, it is assumed that no error has occurred and both error flags will be low. (It should be noted that the sense of two of the check bits, bits CB0 and CB1, is inverted to ensure that the gross-error condition of all lows and all highs is detected.)

If the parity of one or more of the check groups is incorrect, an error has occurred and the proper error flag or flags will be set high. Any single error in the 16-bit data word will change the sense of exactly three bits of the 6-bit check word. Any single error in the 6-bit check word changes the sense of only that one bit. In either case, the single error flag will be set high while the dual error flag will remain low.

Any two-bit error will change the sense of an even number of check bits. The two-bit error is not correctable since the parity tree can only identify single-bit errors. Both error flags are set high when any two-bit error is detected.

Three or more simultaneous bit errors can fool the EDAC into believing that no error, a correctable error, or an uncorrectable error has occurred and produce erroneous results in all three cases.

Error correction is accomplished by identifying the bad bit and inverting it. Identification of the erroneous bit is achieved by comparing the 16-bit data word and 6-bit check word from memory with the new check word with one (check word error) or three (data word error) inverted bits.

As the corrected word is made available on the data word I/O port, the check word I/O port presents a 6-bit syndrome error code. This syndrome code can be used to identify the bad memory chip.

**TYPES SN54HC630, SN74HC630**  
**16-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS**

**ERROR SYNDROME TABLE**

ERROR LOCATION	SYNDROME ERROR CODE					
	CB0	CB1	CB2	CB3	CB4	CB5
DB0	L	L	H	L	H	H
DB1	L	H	L	L	H	H
DB2	H	L	L	L	H	H
DB3	L	L	H	H	L	H
DB4	L	H	L	H	L	H
DB5	H	L	L	H	L	H
DB6	H	L	H	L	L	H
DB7	H	H	L	L	L	H
DB8	L	L	H	H	H	L
DB9	L	H	L	H	H	L
DB10	L	H	H	L	H	L
DB11	H	L	H	L	H	L
DB12	H	H	L	L	H	L
DB13	L	H	H	H	L	L
DB14	H	L	H	H	L	L
DB15	H	H	L	H	L	L
CB0	L	H	H	H	H	H
CB1	H	L	H	H	H	H
CB2	H	H	L	H	H	H
CB3	H	H	H	L	H	H
CB4	H	H	H	H	L	H
CB5	H	H	H	H	H	L
NO ERROR	H	H	H	H	H	H

maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.



- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Detects and Corrects Single-Bit Errors
- Detects and Flags Dual-Bit Errors
- Built-In Diagnostic Capability
- Fast Write and Read Cycle Processing Times
- Byte-Write Capability
- Dependable Texas Instruments Quality and Reliability

#### description

The 'HC632 is a 32-bit parallel error detection and correction circuit (EDAC) in a 52-pin, 600-mil package. It uses a modified Hamming code to generate a 7-bit check word from a 32-bit data word. This check word is stored along with the data word during the memory write cycle. During the memory read cycle, the 39-bit words from memory are processed by the EDAC to determine if errors have occurred in memory.

Single-bit errors in the 32-bit data word are flagged and corrected.

Single-bit errors in the 7-bit check word are flagged, and the CPU sends the EDAC through the correction cycle even though the 32-bit data word is not in error. The correction cycle will simply pass along the original 32-bit data word in this case and produce error syndrome bits to pinpoint the error-generating location.

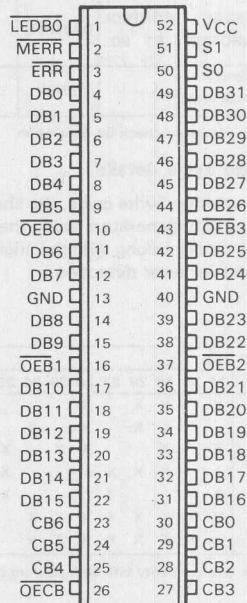
Dual-bit errors are flagged but not corrected. These errors may occur in any two bits of the 39-bit word from memory (two errors in the 32-bit data word, two errors in the 7-bit check word, or one error in each word). The gross-error condition of all lows or all highs from memory will be detected. Otherwise, errors in three or more bits of the 39-bit word are beyond the capabilities of these devices to detect.

Read-modify-write (byte-control) operations can be performed with the 'HC632 EDAC by using output latch enable, LEDBO, and the individual OEB0 thru OEB3 byte control pins.

Diagnostics are performed on the EDAC by controls and internal paths that allow the user to read the contents of the DB and CB input latches. These will determine if the failure occurred in memory or in the EDAC.

The SN54HC632 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC632 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

'HC632 . . . JD OR N PACKAGES  
(TOP VIEW)



FOR CHIP CARRIER INFORMATION,  
CONTACT THE FACTORY.

PRODUCT PREVIEWS

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#### PRODUCT PREVIEW

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# TYPES SN54HC632, SN74HC632

## 32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

TABLE I. WRITE CONTROL FUNCTION

MEMORY CYCLE	EDAC FUNCTION	CONTROL S1 S0	DATA I/O	DB CONTROL OEBO THRU OEB3	DB OUTPUT LATCH LEDBO	CHECK I/O	CB CONTROL OECB	ERROR FLAGS ERR MERR
Write	Generate check word	L L	Input	H	X	Output check bits†	L	H H

†See Table II for details on check bit generation.

### memory write cycle details

During a memory write cycle, the check bits (CB0 thru CB6) are generated internally in the EDAC by seven 16-input parity generators using the 32-bit data word as defined in Table II. These seven check bits are stored in memory along with the original 32-bit data word. This 32-bit word will later be used in the memory read cycle for error detection.

TABLE II. PARITY ALGORITHM

CHECK WORD	32-BIT DATA WORD																																			
BIT	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
CB0	X		X	X		X					X		X	X	X		X		X		X		X	X	X	X		X		X		X				
CB1				X				X		X		X		X	X	X				X		X			X		X		X		X		X			
CB2	X		X			X	X		X		X	X				X	X		X			X	X		X			X		X		X		X		
CB3			X	X	X					X	X	X			X	X			X	X	X					X	X	X				X		X		
CB4	X	X								X	X	X	X	X			X	X									X	X	X	X	X	X		X		
CB5	X	X	X	X	X	X	X	X									X	X	X	X	X	X	X	X												
CB6	X	X	X	X	X	X	X	X	X																		X	X	X	X	X	X	X			

The seven check bits are parity bits derived from the matrix of data bits as indicated by "X" for each bit.

### error detection and correction details

During a memory read cycle, the 7-bit check word is retrieved along with the actual data. In order to be able to determine whether the data from memory is acceptable to use as presented to the bus, the error flags must be tested to determine if they are at the high level.

The first case in Table III represents the normal, no-error conditions. The EDAC presents highs on both flags. The next two cases of single-bit errors give a high on MERR and a low on ERR, which is the signal for a correctable error, and the EDAC should be sent through the correction cycle. The last three cases of double-bit errors will cause the EDAC to signal lows on both ERR and MERR, which is the interrupt indication for the CPU.

TABLE III. ERROR FUNCTION

TOTAL NUMBER OF ERRORS		ERROR FLAGS		DATA CORRECTION
32-BIT DATA WORD	7-BIT CHECK WORD	ERR	MERR	
0	0	H	H	Not applicable
1	0	L	H	Correction
0	1	L	H	Correction
1	1	L	L	Interrupt
2	0	L	L	Interrupt
0	2	L	L	Interrupt

## TYPES SN54HC632, SN74HC632

### 32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

Error detection is accomplished as the 7-bit check word and the 32-bit data word from memory are applied to internal parity generators/checkers. If the parity of all seven groupings of data and check bits are correct, it is assumed that no error has occurred and both error flags will be high.

If the parity of one or more of the check groups is incorrect, an error has occurred and the proper error flag or flags will be set low. Any single error in the 32-bit data word will change the state of either three or five bits of the 7-bit check word. Any single error in the 7-bit check word changes the state of only that one bit. In either case, the single error flag (ERR) will be set low while the dual error flag (MERR) will remain high.

Any two-bit error will change the state of an even number of check bits. The two-bit error is not correctable since the parity tree can only identify single-bit errors. Both error flags are set low when any two-bit error is detected.

Three or more simultaneous bit errors can cause the EDAC to believe that no error, a correctable error, or an uncorrectable error has occurred and will produce erroneous results in all three cases. It should be noted that the gross-error conditions of all lows and all highs will be detected.

TABLE IV. READ, FLAG, AND CORRECT FUNCTION

MEMORY CYCLE	EDAC FUNCTION	CONTROL S1 S0	DATA I/O	DB CONTROL OEB0 THRU OEB3	DB OUTPUT LATCH LEDB0	CHECK I/O	CB CONTROL OECB	ERROR FLAGS ERR MERR
Read	Read & flag	H L	Input	H	X	Input	H	Enabled†
Read	Latch input data & check bits	H H	Latched input data	H	L	Latched input check word	H	Enabled†
Read	Output corrected data & syndrome bits	H H	Output corrected data word	L	X	Output syndrome bits‡	L	Enabled†

†See Table III for error description.

‡See Table V for error location.

As the corrected word is made available on data I/O port (DB0 thru DB31), the check word I/O port (CB0 thru CB6) presents a 7-bit syndrome error code. This syndrome error code can be used to locate the bad memory chip. See Table V for syndrome decoding.

PRODUCT PREVIEW

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## PRODUCT PREVIEWS

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SYNDROME BITS							ERROR	SYNDROME BITS							ERROR	SYNDROME BITS							ERROR
6	5	4	3	2	1	0		6	5	4	3	2	1	0		6	5	4	3	2	1	0	
L	L	L	L	L	L	L	unc	L	H	L	L	L	L	L	2-bit	H	H	L	L	L	L	L	unc
L	L	L	L	L	L	L	2-bit	L	H	L	L	L	L	H	unc	H	H	L	L	L	L	H	2-bit
L	L	L	L	L	L	H	2-bit	L	H	L	L	L	H	L	DB7	H	L	L	L	L	H	L	2-bit
L	L	L	L	L	H	H	unc	L	H	L	L	L	H	H	2-bit	H	L	L	L	L	H	H	DB23
L	L	L	L	L	H	L	2-bit	L	H	L	L	H	L	L	DB6	H	L	L	L	H	L	L	unc
L	L	L	L	H	L	H	unc	L	H	L	L	H	L	H	2-bit	H	L	L	L	H	L	H	2-bit
L	L	L	L	H	H	L	unc	L	H	L	L	H	H	L	2-bit	H	L	L	L	H	H	L	2-bit
L	L	L	L	H	H	H	2-bit	L	H	L	L	H	H	H	DB5	H	L	L	L	H	H	H	unc
L	L	L	H	L	L	L	2-bit	L	H	L	H	L	L	L	DB4	H	L	L	H	L	L	L	unc
L	L	L	H	L	L	L	unc	L	H	L	H	L	L	H	2-bit	H	L	L	H	L	L	H	2-bit
L	L	L	H	L	L	H	DB31	L	H	L	H	L	L	H	2-bit	H	L	L	H	L	L	H	2-bit
L	L	L	H	L	H	H	2-bit	L	H	L	H	L	H	H	DB3	H	L	L	H	L	H	H	DB15
L	L	L	H	H	L	L	unc	L	H	L	H	H	L	L	2-bit	H	L	L	H	H	L	L	2-bit
L	L	L	H	H	L	H	2-bit	L	H	L	H	H	L	H	DB2	H	L	L	H	H	L	H	unc
L	L	L	H	H	H	L	2-bit	L	H	L	H	H	H	L	unc	H	L	L	H	H	H	L	DB14
L	L	L	H	H	H	H	DB30	L	H	L	H	H	H	H	2-bit	H	L	L	H	H	H	H	2-bit
L	L	H	L	L	L	L	2-bit	L	H	H	L	L	L	L	DB0	H	L	H	L	L	L	L	unc
L	L	H	L	L	L	L	unc	L	H	H	L	L	L	H	2-bit	H	L	H	L	L	L	H	2-bit
L	L	H	L	L	L	L	DB29	L	H	H	L	L	L	H	2-bit	H	L	H	L	L	L	H	2-bit
L	L	H	L	L	L	H	2-bit	L	H	H	L	L	H	H	unc	H	L	H	L	L	H	H	DB13
L	L	H	L	H	L	L	DB28	L	H	H	L	H	L	L	2-bit	H	L	H	L	H	L	L	2-bit
L	L	H	L	H	L	H	2-bit	L	H	H	L	H	L	H	DB1	H	L	H	L	H	L	H	DB12
L	L	H	L	H	L	L	2-bit	L	H	H	L	H	L	L	unc	H	L	H	L	H	L	L	DB11
L	L	H	L	H	H	H	DB27	L	H	H	L	H	H	H	2-bit	H	L	H	L	H	H	H	2-bit
L	L	H	H	L	L	L	DB26	L	H	H	H	L	L	L	2-bit	H	L	H	H	L	L	L	2-bit
L	L	H	H	L	L	H	2-bit	L	H	H	H	L	L	H	unc	H	L	H	H	L	L	H	DB10
L	L	H	H	L	L	L	2-bit	L	H	H	H	L	L	L	unc	H	L	H	H	L	L	L	DB9
L	L	H	L	L	H	H	DB25	L	H	H	L	L	H	H	2-bit	H	L	H	L	H	H	H	2-bit
L	L	H	H	H	L	L	2-bit	L	H	H	H	H	L	L	unc	H	L	H	H	H	L	L	DB8
L	L	H	H	H	L	L	DB24	L	H	H	H	H	L	H	2-bit	H	L	H	H	H	L	H	2-bit
L	L	H	H	H	H	L	unc	L	H	H	H	H	L	L	2-bit	H	L	H	H	H	H	L	2-bit
L	L	H	H	H	H	H	2-bit	L	H	H	H	H	H	H	CB6	H	L	H	H	H	H	H	CB5

CB X = error in check bit X  
DB Y = error in data bit Y  
2-bit = double-bit error  
unc = uncorrectable multibit error

**read-modify-write (byte control) operations**

The 'HC632 is capable of byte-write operations. The 39-bit word from memory must first be latched into the DB and CB input latches. This is easily accomplished by switching from the read and flag mode (S1 = H, S0 = L) to the latch input mode (S1 = H, S0 = H). The EDAC will then make any corrections, if necessary, to the data word and place it at the input of the output data latch. This data word must then be latched into the output data latch by taking LEDB0 from a low to a high.

Byte control can now be employed on the data word through the  $\overline{\text{OE}}\text{B}0$  through  $\overline{\text{OE}}\text{B}3$  controls.  $\overline{\text{OE}}\text{B}0$  controls DB0—DB7 (byte 0),  $\overline{\text{OE}}\text{B}1$  controls DB8—DB15 (byte 1),  $\overline{\text{OE}}\text{B}2$  controls DB16—DB23 (byte 2), and  $\overline{\text{OE}}\text{B}3$  controls DB24—DB31 (byte 3). Placing a high on the byte control will disable the output and the user can modify the byte. If a low is placed on the byte control, then the original byte is allowed to pass onto the data bus unchanged. If the original data word is altered through byte control, a new check word must be generated before it is written back into memory. This is easily accomplished by taking control S1 and S0 low. Table VI lists the read-modify-write functions.



# TYPES SN54HC632, SN74HC632 32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

TABLE VI. READ-MODIFY-WRITE FUNCTION

MEMORY CYCLE	EDAC FUNCTION	CONTROL S1 S0	BYTEN†	$\overline{OEB}n†$	DB OUTPUT LATCH $\overline{LEDBO}$	CHECK I/O	CB CONTROL	ERROR FLAG ERR MERR
Read	Read & Flag	H L	Input	H	X	Input	H	Enabled
Read	Latch input data & check bits	H H	Latched Input data	H	L	Latched input check word	H	Enabled
Read	Latch corrected data word into output latch	H H	Latched output data word	H	H	Hi-Z Output Syndrome bits	H L	Enabled
Modify /write	Modify appropriate byte or bytes & generate new check word	L L	Input modified BYTE0 Output unchanged BYTE0	H L	H	Output check word	L	H H

† $\overline{OEB}0$  controls DB0—DB7 (BYTE0),  $\overline{OEB}1$  controls DB8—DB15 (BYTE1),  $\overline{OEB}2$  controls DB16—DB23 (BYTE2),  $\overline{OEB}3$  controls DB24—DB31 (BYTE3).

## diagnostic operations

The 'HC632 is capable of diagnostics that will allow the user to determine whether the EDAC or the memory is failing. The diagnostic function tables will help the user to see the possibilities for diagnostic control.

In the diagnostic mode (S1 = L, S0 = H), the checkword is latched into the input latch while the data input latch remains transparent. This lets the user apply various data words against a fixed known checkword. If the user applies a diagnostic data word with an error in any bit location, the ERR flag should be low. If a diagnostic data word with two errors in any bit location is applied, the MERR flag should be low. After the checkword is latched into the input latch, it can be verified by taking  $\overline{OECB}$  low. This outputs the latched checkword. The diagnostic data word can be latched into the output data latch and verified. By changing from the diagnostic mode (S1 = L, S0 = H) to the correction mode (S1 = H, S0 = H), the user can verify that the EDAC will correct the diagnostic data word. Also, the syndrome bits can be produced to verify that the EDAC pinpoints the error location. Table VII lists the diagnostic functions.

# **TYPES SN54HC632, SN74HC632** **32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS**

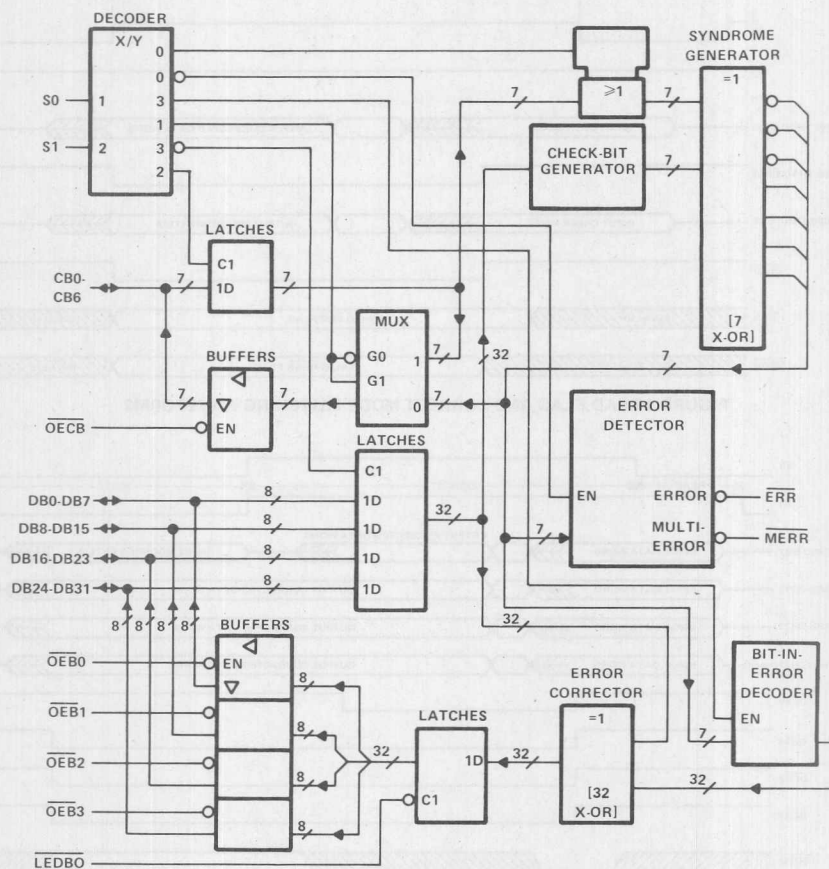
TABLE VII. DIAGNOSTIC FUNCTION

EDAC FUNCTION	CONTROL S1 S0	DATA I/O	DB BYTE CONTROL OEBn	DB OUTPUT LATCH LEDBO	CHECK I/O	CB CONTROL OECB	ERROR FLAGS ERR MERR
Read & flag	H L	Input correct data word	H	X	Input correct check bits	H	H H
Latch input check word while data input latch remains transparent	L H	Input diagnostic data word <sup>†</sup>	H	L	Latched input check bits	H	Enabled
Latch diagnostic data word into output latch	L H	Input diagnostic data word <sup>†</sup>	H	H	Output latched check bits Hi-Z	L H	Enabled
Latch diagnostic data word into input latch	H H	Latched input diagnostic data word	H	H	Output syndrome bits Hi-Z	L H	Enabled
Output diagnostic data word & syndrome bits	H H	Output diagnostic data word	L	H	Output syndrome bits Hi-Z	L H	Enabled
Output corrected diagnostic data word & output syndrome bits	H H	Output corrected diagnostic data word	L	L	Output syndrome bits Hi-Z	L H	Enabled

<sup>†</sup> Diagnostic data is a data word with an error in one bit location except when testing the MERR error flag. In this case, the diagnostic data word will contain errors in two bit locations.

**TYPES SN54HC632, SN74HC632**  
**32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS**

logic diagram (positive logic)



maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

PRODUCT PREVIEWS

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**TYPES SN54HC632, SN74HC632**  
**32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS**

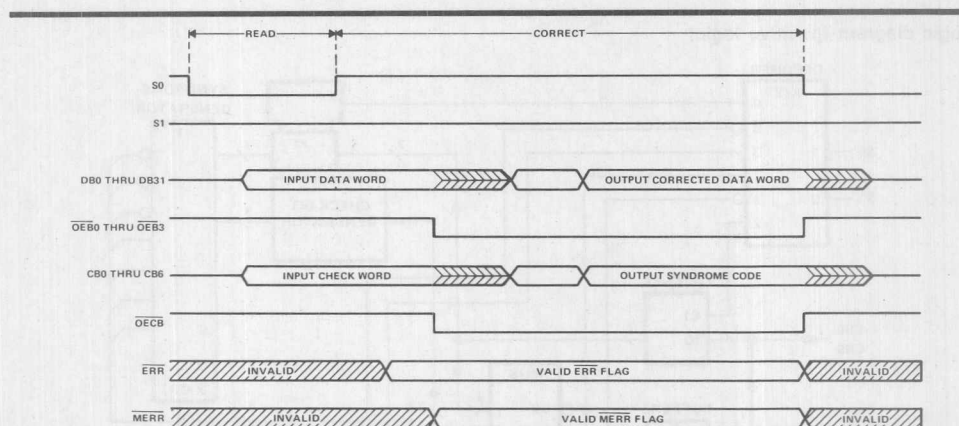


FIGURE 1-READ, FLAG, AND CORRECT MODE SWITCHING WAVEFORMS

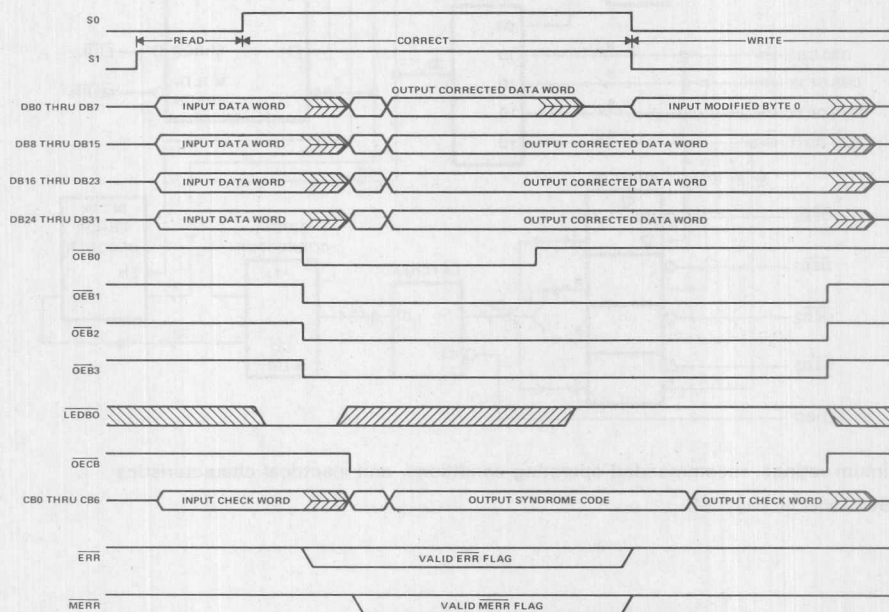


FIGURE 2-READ, CORRECT, MODIFY MODE SWITCHING WAVEFORMS

# TYPES SN54HC632, SN74HC632 32-BIT PARALLEL ERROR DETECTION AND CORRECTION CIRCUITS

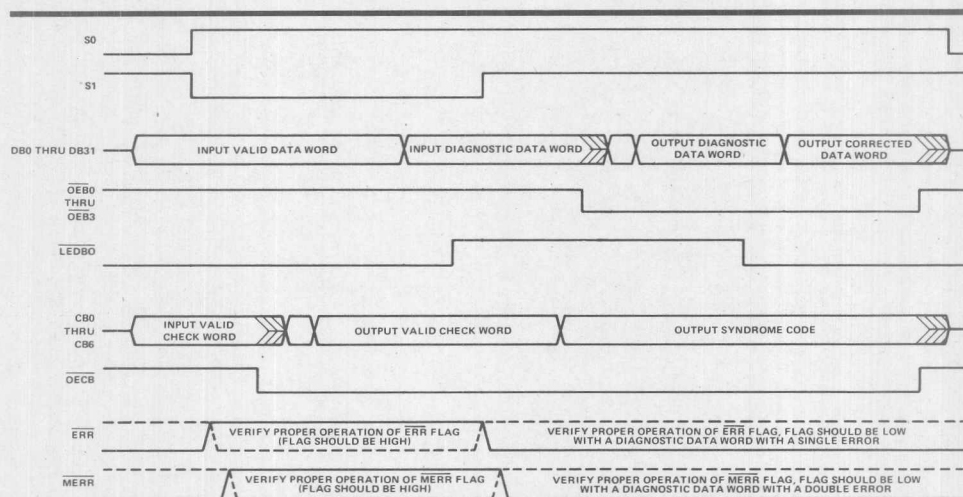


FIGURE 3-DIAGNOSTIC MODE SWITCHING WAVEFORM

# PRODUCT PREVIEWS

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# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC670, SN74HC670 4-BY-4 REGISTER FILES WITH 3-STATE OUTPUTS

D2804, MARCH 1984

- Separate Read/Write Addressing Permits Simultaneous Reading and Writing
- Organized as 4 Words of 4 Bits
- Expandable to 512 Words of n-Bits
- For Use as:
  - Scratch-Pad Memory
  - Buffer Storage Between Processors
  - Bit Storage in Fast Multiplication Designs
- High-Current 3-State Outputs Can Drive up to 15 LSTTL Loads
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

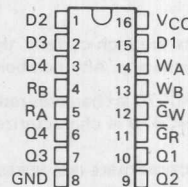
### description

The SN54HC670 and SN74HC670 are 16-bit register files. The register file is organized as 4 words of 4 bits each and separate on-chip decoding is provided for addressing the four word locations to either write-in or retrieve data. This permits simultaneous writing into one location and reading from another word location.

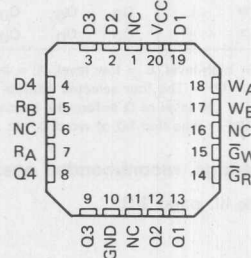
Four data inputs are used to supply the 4-bit word to be stored. Location of the word is determined by the write-address inputs  $W_A$  and  $W_B$  in conjunction with a write-enable signal  $\overline{G_W}$ . Data applied at the inputs should be in its true form. That is, if a high-level signal is desired from the output, a high-level is applied at the data input for that particular bit location. When  $\overline{G_W}$  is high, the data inputs are inhibited and their levels can cause no change in the information stored in the internal latches. When the read-enable input  $\overline{G_R}$  is high, the data outputs are inhibited and go into the high-impedance state.

The individual address lines permit direct acquisition of data stored in any four of the latches. Four individual decoding gates are used to complete the address for reading a word. When the read address is made in conjunction with the read-enable signal, the word appears at the four outputs.

SN54HC670...J PACKAGE  
SN74HC670...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

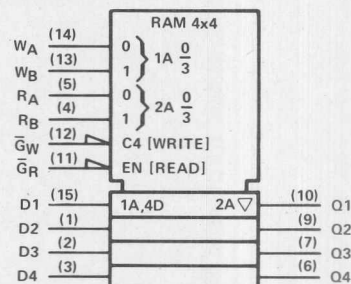


SN54HC670...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connections.

### logic symbol



Pin numbers shown are for J and N packages.

PRODUCT PREVIEWS

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### PRODUCT PREVIEW

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TEXAS  
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## TYPES SN54HC670, SN74HC670

### 4-BY-4 REGISTER FILES WITH 3-STATE OUTPUTS

This arrangement—data-entry addressing separate from data-read addressing and individual sense line—eliminates recovery times, permits simultaneous reading and writing, and is limited in speed only by the write time and the read time. The register file has a nondestructive readout in that data is not lost when addressed.

The outputs are high-current, three-state outputs. These outputs may be bus connected for increasing the word capacity. Any number of these registers may be paralleled to provide n-bit word length.

The SN54HC670 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC670 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

WRITE FUNCTION TABLE (SEE NOTES A, B, AND C)

WRITE INPUTS			WORD			
W <sub>B</sub>	W <sub>A</sub>	W <sub>V</sub>	0	1	2	3
L	L	L	Q = D	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>
L	H	L	Q <sub>0</sub>	Q = D	Q <sub>0</sub>	Q <sub>0</sub>
H	L	L	Q <sub>0</sub>	Q <sub>0</sub>	Q = D	Q <sub>0</sub>
H	H	L	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>	Q = D
X	X	H	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>	Q <sub>0</sub>

READ FUNCTION TABLE (SEE NOTES A AND D)

READ INPUTS			OUTPUTS			
R <sub>B</sub>	R <sub>A</sub>	R <sub>V</sub>	Q1	Q2	Q3	Q4
L	L	L	W0B1	W0B2	W0B3	W0B4
L	H	L	W1B1	W1B2	W1B3	W1B4
H	L	L	W2B1	W2B2	W2B3	W2B4
H	H	L	W3B1	W3B2	W3B3	W3B4
X	X	H	Z	Z	Z	Z

- NOTES: A. H = high level, L = low level, X = irrelevant, Z = high impedance (off)  
 B. (Q = D) = The four selected internal flip-flop outputs will assume the states applied to the four external data inputs.  
 C. Q<sub>0</sub> = the level of Q before the indicated input conditions were established.  
 D. W0B1 = The first bit of word 0, etc.

#### maximum ratings, recommended operating conditions, and electrical characteristics

See Table III, page 2-8.

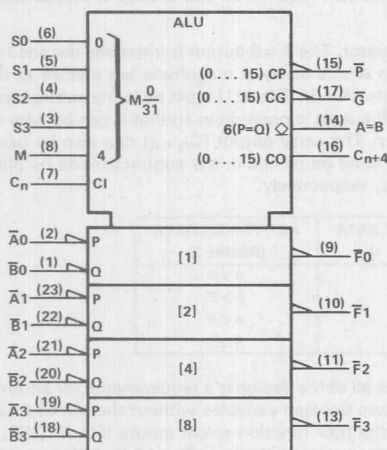
# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC181, SN54HC881 SN74HC181, SN74HC881 ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

D2804, MARCH 1984

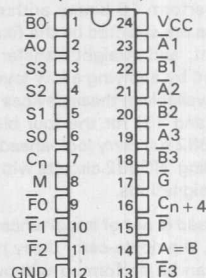
- Full Look-Ahead for High-Speed Operations on Long Words
- Arithmetic Operating Modes
  - Addition
  - Subtraction
  - Shift Operand A One Position
  - Magnitude Comparison
  - Plus Twelve Other Arithmetic Operations
- Logic Function Modes
  - Exclusive-OR
  - Comparator
  - AND, NAND, OR, NOR
  - 'HC881 Provides Status Register Checks
  - Plus Ten Other Logic Operations
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### **logic symbol**

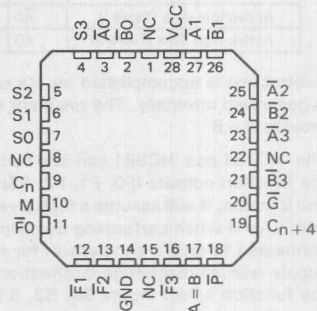


Pin numbers shown are for JT and NT packages.

### **SN54HC181, SN54HC881... JT PACKAGE SN74HC181, SN74HC881... JT OR NT OR D (= SO) PACKAGE (TOP VIEW)**



### **SN54HC181, SN54HC881... FH OR FK PACKAGE (TOP VIEW)**



NC—No internal connection

**PRODUCT PREVIEWS**

**5**

### **PRODUCT PREVIEW**

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# description

The 'HC181 and 'HC881 are arithmetic logic units (ALU)/function generators on a monolithic chip. These circuits perform 16 binary arithmetic operations on two 4-bit words as shown in Tables I and II. These operations are selected by the four function-select lines (S0, S1, S2, S3) and include addition, subtraction, decrement, and straight transfer. When performing arithmetic manipulations, the internal carriers must be enabled by applying a low-level voltage to the mode control input (M). A full carry look-ahead scheme is made available in these devices for fast, simultaneous carry generation by means of two cascade-outputs (pins 15 and 17) for the four bits in the package. When used in conjunction with the SN54HC882 or SN74HC882 full carry look-ahead circuits, high-speed arithmetic operations can be performed. The method of cascading 'HC882 circuits with these ALUs to provide multilevel full carry look-ahead is illustrated under signal designations.

If high speed is not of importance, a ripple-carry input ( $C_n$ ) and a ripple-carry output ( $C_{n+4}$ ) are available. However, the ripple-carry delay has also been minimized so that arithmetic manipulations for small word lengths can be performed without external circuitry.

The 'HC181 and 'HC881 will accommodate active-high or active-low data if the pin designations are interpreted as follows:

PIN NUMBER	2	1	23	22	21	20	19	18	9	10	11	13	7	16	15	17
Active-low data (Table I)	$\bar{A}0$	$\bar{B}0$	$\bar{A}1$	$\bar{B}1$	$\bar{A}2$	$\bar{B}2$	$\bar{A}3$	$\bar{B}3$	$\bar{F}0$	$\bar{F}1$	$\bar{F}2$	$\bar{F}3$	$C_n$	$C_{n+4}$	$\bar{P}$	$\bar{G}$
Active-high data (Table II)	A0	B0	A1	B1	A2	B2	A3	B3	F0	F1	F2	F3	$C_n$	$C_{n+4}$	X	Y

Subtraction is accomplished by 1's complement addition where the 1's complement of the subtrahend is generated internally. The resultant output is  $A - B - 1$ , which requires an end-around or forced carry to provide  $A - B$ .

The 'HC181 and 'HC881 can also be utilized as a comparator. The  $A = B$  output is internally decoded from the function outputs (F0, F1, F2, F3) so that when two words of equal magnitude are applied at the A and B inputs, it will assume a high level to indicate equality ( $A = B$ ). The ALU must be in the subtract mode with  $C_n = H$  when performing this comparison. The  $A = B$  output is open-drain so that it can be wire-AND connected to give a comparison for more than four bits. The carry output ( $C_{n+4}$ ) can also be used to supply relative magnitude information. Again, the ALU must be placed in the subtract mode by placing the function select inputs S3, S2, S1, S0 at L, H, H, L, respectively.

INPUT $C_n$	OUTPUT $C_{n+4}$	ACTIVE-LOW DATA (FIGURE 1)	ACTIVE-HIGH DATA (FIGURE 2)
H	H	$A \geq B$	$A \leq B$
H	L	$A < B$	$A > B$
L	H	$A > B$	$A < B$
L	L	$A \leq B$	$A \geq B$

These circuits have been designed to not only incorporate all of the designer's requirements for arithmetic operations, but also to provide 16 possible functions of two Boolean variables without the use of external circuitry. These logic functions are selected by use of the four function-select inputs (S0, S1, S2, S3) with the mode-control input (M) at a high level to disable the internal carry. The 16 logic functions are detailed in Tables I and II and include Exclusive-OR, NAND, AND, NOR, and OR functions.

The 'HC881 has the same pinout and same functionality as the 'HC181 except for the  $\bar{P}$ ,  $\bar{G}$ , and  $C_{n+4}$  outputs when the device is in the logic mode ( $M = H$ ).

**TYPES SN54HC181, SN54HC881  
SN74HC181, SN74HC881  
ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

In the logic mode the 'HC881 provides the user with a status check on the input words, A and B, and the output word F. While in the logic mode the  $\bar{P}$ ,  $\bar{G}$ , and  $C_{n+4}$  outputs supply status information based upon the following logical combinations:

$$\bar{P} = F_0 + F_1 + F_2 + F_3$$

$$\bar{G} = H$$

$$C_{n+4} = PC_n$$

FUNCTION TABLE FOR INPUT BITS EQUAL/NOT EQUAL

$S_0 = S_3 = H$ ,  $S_1 = S_2 = L$ , and  $M = H$

$C_n$	DATA INPUTS				OUTPUTS		
	$\bar{A}_0 = \bar{B}_0$	$\bar{A}_1 = \bar{B}_1$	$\bar{A}_2 = \bar{B}_2$	$\bar{A}_3 = \bar{B}_3$	$\bar{G}$	$\bar{P}$	$C_{n+4}$
H	$\bar{A}_0 = \bar{B}_0$	$\bar{A}_1 = \bar{B}_1$	$\bar{A}_2 = \bar{B}_2$	$\bar{A}_3 = \bar{B}_3$	H	L	H
L	$\bar{A}_0 = \bar{B}_0$	$\bar{A}_1 = \bar{B}_1$	$\bar{A}_2 = \bar{B}_2$	$\bar{A}_3 = \bar{B}_3$	H	L	L
X	$\bar{A}_0 \neq \bar{B}_0$	X	X	X	H	H	L
X	X	$\bar{A}_1 \neq \bar{B}_1$	X	X	H	H	L
X	X	X	$\bar{A}_2 \neq \bar{B}_2$	X	H	H	L
X	X	X	X	$\bar{A}_3 \neq \bar{B}_3$	H	H	L

FUNCTION TABLE FOR INPUT PAIRS HIGH/NOT HIGH

$S_0 = S_1 = S_3 = L$ ,  $S_2 = H$ , and  $M = H$

$C_n$	DATA INPUTS				OUTPUTS		
	$\bar{A}_0$ or $\bar{B}_0 = L$	$\bar{A}_1$ or $\bar{B}_1 = L$	$\bar{A}_2$ or $\bar{B}_2 = L$	$\bar{A}_3$ or $\bar{B}_3 = L$	$\bar{G}$	$\bar{P}$	$C_{n+4}$
H	$\bar{A}_0$ or $\bar{B}_0 = L$	$\bar{A}_1$ or $\bar{B}_1 = L$	$\bar{A}_2$ or $\bar{B}_2 = L$	$\bar{A}_3$ or $\bar{B}_3 = L$	H	L	H
L	$\bar{A}_0$ or $\bar{B}_0 = L$	$\bar{A}_1$ or $\bar{B}_1 = L$	$\bar{A}_2$ or $\bar{B}_2 = L$	$\bar{A}_3$ or $\bar{B}_3 = L$	H	L	L
X	$\bar{A}_0 = \bar{B}_0 = H$	X	X	X	H	H	L
X	X	$\bar{A}_1 = \bar{B}_1 = H$	X	X	H	H	L
X	X	X	$\bar{A}_2 = \bar{B}_2 = H$	X	H	H	L
X	X	X	X	$\bar{A}_3 = \bar{B}_3 = H$	H	H	L

The combination of signals on the S3 through S0 control lines determine the operation performed on the data words to generate the output bits  $\bar{F}_i$ . By monitoring the  $\bar{P}$  and  $C_{n+4}$  outputs, the user can determine if all pairs of input bits are equal (see table above) or if any pair of inputs are both high (see table above). The 'HC881 has the unique feature of providing an  $A = B$  status while the Exclusive-OR ( $\oplus$ ) function is being utilized. When the control inputs (S3, S2, S1, S0) equal H, L, L, H; a status check is generated to determine whether all pairs ( $\bar{A}_i$ ,  $\bar{B}_i$ ) are equal in the following manner:  $\bar{P} = (A_0 \oplus B_0) + (A_1 \oplus B_1) + (A_2 \oplus B_2) + (A_3 \oplus B_3)$ . This unique bit-by-bit comparison of the data words, which is available on the totem-pole  $\bar{P}$  output, is particularly useful when cascading 'HC881's. As the  $A = B$  condition is sensed in the first stage, the signal is propagated through the same ports used for carry generation in the arithmetic mode ( $\bar{P}$  and  $\bar{G}$ ). Thus the  $A = B$  status is transmitted to the second stage more quickly without the need for external multiplexing logic. The  $A = B$  open-drain output allows the user to check the validity of the bit-by-bit result by comparing the two signals for parity.

If the user wishes to check for any pair of data inputs ( $\bar{A}_i$ ,  $\bar{B}_i$ ) being high, it is necessary to set the control lines (S3, S2, S1, S0) to L, H, L, L. The data pairs will then be ANDed together and the results ORed in the following manner:  $\bar{P} = \bar{A}_0\bar{B}_0 + \bar{A}_1\bar{B}_1 + \bar{A}_2\bar{B}_2 + \bar{A}_3\bar{B}_3$ .

S3	S2	S1	S0	M	$\bar{P} = F_0 + F_1 + F_2 + F_3$
L	H	L	L	H	$\bar{A}_0\bar{B}_0 + \bar{A}_1\bar{B}_1 + \bar{A}_2\bar{B}_2 + \bar{A}_3\bar{B}_3$
H	L	L	H	H	$(A_0 \oplus B_0) + (A_1 \oplus B_1) + (A_2 \oplus B_2) + (A_3 \oplus B_3)$

The SN54HC181 and SN54HC881 are characterized for operation over the full military temperature range of  $-55^\circ\text{C}$  to  $125^\circ\text{C}$ . The SN74HC181 and SN74HC881 are characterized for operation from  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .



**TYPES SN54HC181, SN54HC881  
SN74HC181, SN74HC881  
ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

**signal designations**

In both Figures 1 and 2, the polarity indicators (  $\triangle$  ) indicate that the associated input or output is active-low with respect to the function shown inside the symbol and the symbols are the same in both figures. The signal designations in Figure 1 agree with the indicated internal functions based on active-low data, and are for use with the logic functions and arithmetic operations shown in Table I. The signal designations have been changed in Figure 2 to accommodate the logic functions and arithmetic operations for the active-high data given in Table II. The 'HC181 and 'HC881 together with the 'HC182 and 'HC882 can be used with the signal designation of either Figure 1 or Figure 2.

PRODUCT PREVIEWS

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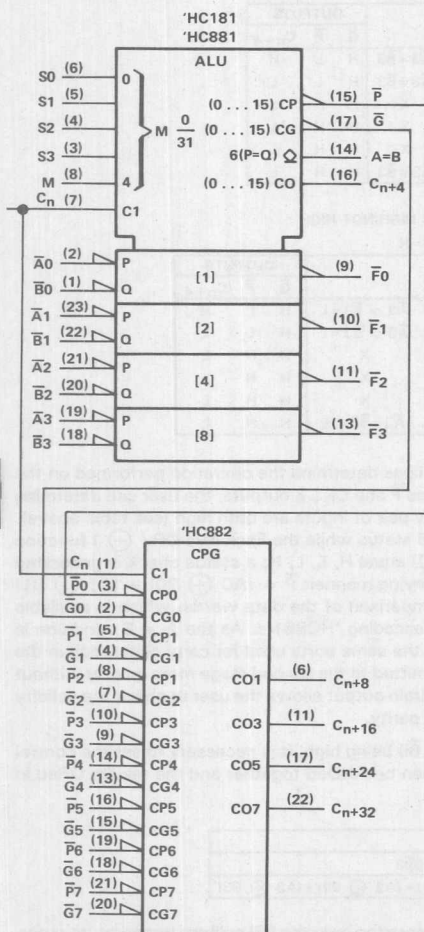


FIGURE 1  
(USE WITH TABLE I)

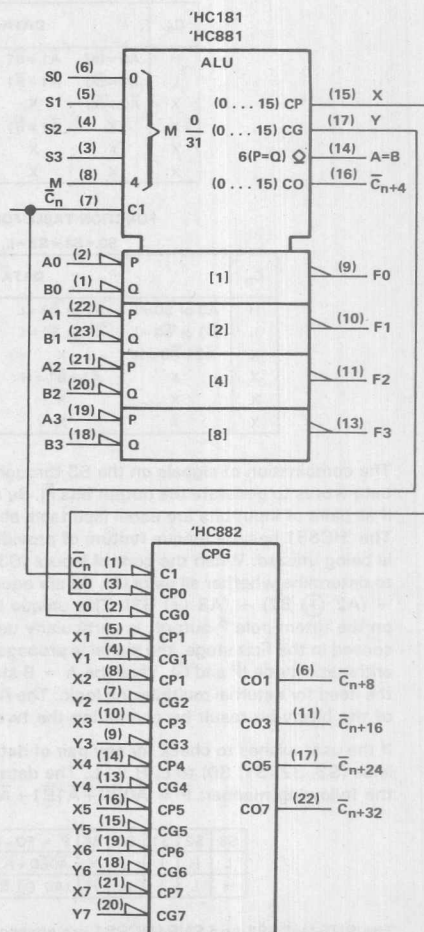


FIGURE 2  
(USE WITH TABLE II)



**TYPES SN54HC181, SN54HC881  
SN74HC181, SN74HC881**

**ARITHMETIC LOGIC UNITS/FUNCTION GENERATORS**

TABLE I

SELECTION					ACTIVE-LOW DATA		
					M = H	M = L; ARITHMETIC OPERATIONS	
S3	S2	S1	S0	LOGIC FUNCTIONS		C <sub>n</sub> = L (no carry)	C <sub>n</sub> = H (with carry)
L	L	L	L	$F = \bar{A}$		F = A MINUS 1	F = A
L	L	L	H	$F = \bar{A}\bar{B}$		F = AB MINUS 1	F = AB
L	L	H	L	$F = \bar{A} + B$		F = $\bar{A}\bar{B}$ MINUS 1	F = $\bar{A}\bar{B}$
L	L	H	H	F = 1		F = MINUS 1 (2's COMP)	F = ZERO
L	H	L	L	$F = \bar{A} + \bar{B}$		F = A PLUS (A + $\bar{B}$ )	F = A PLUS (A + $\bar{B}$ ) PLUS 1
L	H	L	H	F = B		F = AB PLUS (A + $\bar{B}$ )	F = AB PLUS (A + $\bar{B}$ ) PLUS 1
L	H	H	L	$F = \bar{A} \oplus B$		F = A MINUS B MINUS 1	F = A MINUS B
L	H	H	H	$F = A + \bar{B}$		F = A + $\bar{B}$	F = (A + $\bar{B}$ ) PLUS 1
H	L	L	L	F = $\bar{A}\bar{B}$		F = A PLUS (A + B)	F = A PLUS (A + B) PLUS 1
H	L	L	H	$F = A \oplus B$		F = A PLUS B	F = A PLUS B PLUS 1
H	L	H	L	F = B		F = $\bar{A}\bar{B}$ PLUS (A + B)	F = $\bar{A}\bar{B}$ PLUS (A + B) PLUS 1
H	L	H	H	F = A + B		F = (A + B)	F = (A + B) PLUS 1
H	H	L	L	F = 0		F = A PLUS A*	F = A PLUS A PLUS 1
H	H	L	H	F = $\bar{A}\bar{B}$		F = AB PLUS A	F = AB PLUS A PLUS 1
H	H	H	L	F = AB		F = $\bar{A}\bar{B}$ PLUS A	F = $\bar{A}\bar{B}$ PLUS A PLUS 1
H	H	H	H	F = A		F = A	F = A PLUS 1

TABLE II

SELECTION					ACTIVE-HIGH DATA		
					M = H	M = L; ARITHMETIC OPERATIONS	
S3	S2	S1	S0	LOGIC FUNCTIONS		$\bar{C}_n$ = H (no carry)	$\bar{C}_n$ = L (with carry)
L	L	L	L	$F = \bar{A}$		F = A	F = A PLUS 1
L	L	L	H	$F = \bar{A} + B$		F = A + B	F = (A + B) PLUS 1
L	L	H	L	$F = \bar{A}\bar{B}$		F = A + $\bar{B}$	F = (A + $\bar{B}$ ) PLUS 1
L	L	H	H	F = 0		F = MINUS 1 (2's COMP)	F = ZERO
L	H	L	L	$F = \bar{A}\bar{B}$		F = A PLUS $\bar{A}\bar{B}$	F = A PLUS $\bar{A}\bar{B}$ PLUS 1
L	H	L	H	F = $\bar{B}$		F = (A + B) PLUS $\bar{A}\bar{B}$	F = (A + B) PLUS $\bar{A}\bar{B}$ PLUS 1
L	H	H	L	$F = A \oplus B$		F = A MINUS B MINUS 1	F = A MINUS B
L	H	H	H	F = $\bar{A}\bar{B}$		F = $\bar{A}\bar{B}$ MINUS 1	F = $\bar{A}\bar{B}$
H	L	L	L	$F = \bar{A} + B$		F = A PLUS AB	F = A PLUS AB PLUS 1
H	L	L	H	$F = \bar{A} \oplus B$		F = A PLUS B	F = A PLUS B PLUS 1
H	L	H	L	F = B		F = (A + $\bar{B}$ ) PLUS AB	F = (A + $\bar{B}$ ) PLUS AB PLUS 1
H	L	H	H	F = AB		F = AB MINUS 1	F = AB
H	H	L	L	F = 1		F = A PLUS A*	F = A PLUS A PLUS 1
H	H	L	H	$F = A + \bar{B}$		F = (A + B) PLUS A	A = (A + B) PLUS A PLUS 1
H	H	H	L	F = A + B		F = (A + $\bar{B}$ ) PLUS A	F = (A + $\bar{B}$ ) PLUS A PLUS 1
H	H	H	H	F = A		F = A MINUS 1	F = A

\*Each bit is shifted to the next more significant position.

PRODUCT PREVIEWS

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## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC882, SN74HC882 32-BIT LOOK-AHEAD CARRY GENERATORS

D2804, MARCH 1984

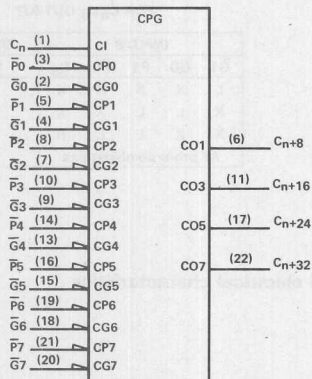
- Directly Compatible with the New 'HC181 and 'HC881ALUs
- Capable of Anticipating the Carry Across a Group of Eight 4-Bit Binary Adders
- Cascadable to Perform Look-Ahead Across n-Bit Adders
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

The 'HC882 is a high-speed look-ahead carry generator capable of anticipating the carry across a group of eight 4-bit adders permitting the designer to implement look-ahead for a 32-bit ALU with a single package or, by cascading 'HC882's, full look-ahead is possible across n-bit adders.

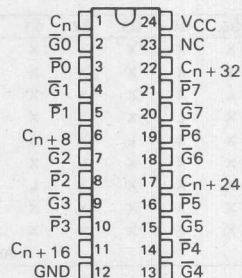
The SN54HC882 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC882 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

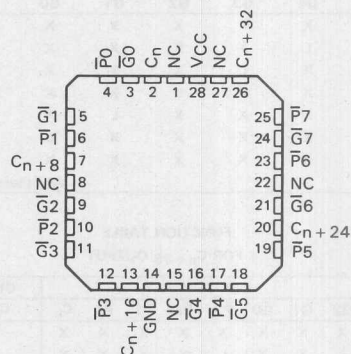


Pin numbers shown are for JT and NT packages.

SN54HC882...JT PACKAGE  
SN74HC882...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC882...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### LOGIC EQUATIONS

$$\begin{aligned}
 C_{n+8} &= G1 + P1G0 + P1P0C_n \\
 C_{n+16} &= G3 + P3G2 + P3P2G1 + P3P2P1G0 \\
 &\quad + P3P2P1P0C_n \\
 C_{n+24} &= G5 + P5G4 + P5P4G3 + P5P4P3G2 \\
 &\quad + P5P4P3P2G1 + P5P4P3P2P1G0 \\
 &\quad + P5P4P3P2P1P0C_n \\
 C_{n+32} &= G7 + P7G6 + P7P6G5 + P7P6P5G4 \\
 &\quad + P7P6P5P4G3 + P7P6P5P4P3G2 \\
 &\quad + P7P6P5P4P3P2G1 + P7P6P5P4P3P2P1G0 \\
 &\quad + P7P6P5P4P3P2P1P0C_n
 \end{aligned}$$

PRODUCT PREVIEWS

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**TYPES SN54HC882, SN74HC882**  
**32-BIT LOOK-AHEAD CARRY GENERATORS**

**FUNCTION TABLE**  
**FOR  $C_{n+32}$  OUTPUT**

INPUTS																	OUTPUT
G7	G6	G5	G4	G3	G2	G1	G0	P7	P6	P5	P4	P3	P2	P1	P0	$C_n$	$C_{n+32}$
L	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	H
X	L	X	X	X	X	X	X	L	X	X	X	X	X	X	X	X	H
X	X	L	X	X	X	X	X	L	L	X	X	X	X	X	X	X	H
X	X	X	L	X	X	X	X	L	L	L	X	X	X	X	X	X	H
X	X	X	X	L	X	X	X	L	L	L	L	X	X	X	X	X	H
X	X	X	X	X	L	X	X	L	L	L	L	L	X	X	X	X	H
X	X	X	X	X	X	L	X	L	L	L	L	L	L	X	X	X	H
X	X	X	X	X	X	X	L	L	L	L	L	L	L	L	X	X	H
X	X	X	X	X	X	X	X	L	L	L	L	L	L	L	L	H	H
All other combinations																	L

**FUNCTION TABLE**  
**FOR  $C_{n+24}$  OUTPUT**

INPUTS													OUTPUT
G5	G4	G3	G2	G1	G0	P5	P4	P3	P2	P1	P0	$C_n$	$C_{n+24}$
L	X	X	X	X	X	X	X	X	X	X	X	X	H
X	L	X	X	X	X	L	X	X	X	X	X	X	H
X	X	L	X	X	X	L	L	X	X	X	X	X	H
X	X	X	L	X	X	L	L	L	X	X	X	X	H
X	X	X	X	L	X	L	L	L	L	X	X	X	H
X	X	X	X	X	L	L	L	L	L	L	X	X	H
X	X	X	X	X	X	L	L	L	L	L	L	H	H
All other combinations													L

**FUNCTION TABLE**  
**FOR  $C_{n+16}$  OUTPUT**

INPUTS									OUTPUT
G3	G2	G1	G0	P3	P2	P1	P0	$C_n$	$C_{n+16}$
L	X	X	X	X	X	X	X	X	H
X	L	X	X	L	X	X	X	X	H
X	X	L	X	L	L	X	X	X	H
X	X	X	L	L	L	L	X	X	H
X	X	X	X	L	L	L	L	H	H
All other combinations									L

**FUNCTION TABLE**  
**FOR  $C_{n+8}$  OUTPUT**

INPUTS					OUTPUT
G1	G0	P1	P0	$C_n$	$C_{n+8}$
L	X	X	X	X	H
X	L	L	X	X	H
X	X	L	L	H	H
All other combinations					L

Any inputs not shown in a given table are irrelevant with respect to that output.

**maximum ratings, recommended operating conditions, and electrical characteristics**

See Table IV, page 2-10.

PRODUCT PREVIEWS

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## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4016, SN74HC4016 QUAD BILATERAL SWITCHES

D2831, MARCH 1984

- High Degree of Linearity
- Switches Can Transmit Signals in Either Direction at Frequencies up to 50 MHz
- Extremely Low Off-State Switch Current Resulting in Very High Effective Off-State Resistance
- High On/Off Output Voltage Ratio
- Extremely High Control-Input Impedance (Control Circuit Isolated from Switch Circuit)
- Low Crosstalk Between Switches
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

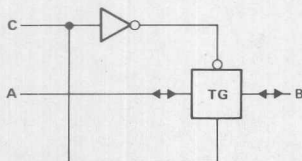
### description

The 'HC4016 is a quadruple bilateral switch for either digital or analog signals. Low power dissipation and high noise immunity allow the 'HC4016 to be used in many diverse environments.

Applications include digital switching and multiplexing, analog-to-digital and digital-to-analog conversion, digital control of frequency, impedance, phase, and analog-signal gain, signal gating, and as a squelch control, chopper, modulator, demodulator, or commutating switch.

The SN54HC4016 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4016 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

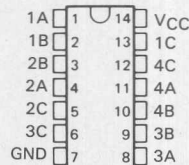
### logic diagram, each switch (positive logic)



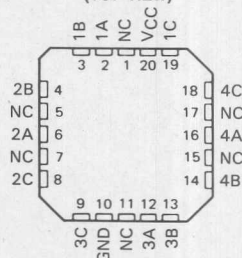
### maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

### SN54HC4016... J PACKAGE SN74HC4016... J OR N OR D (= SO) PACKAGE (TOP VIEW)

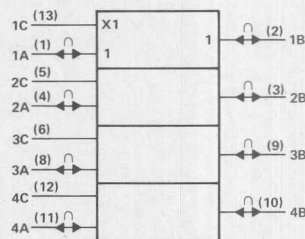


### SN54HC4016... FH OR FK PACKAGE (TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

PRODUCT PREVIEWS

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## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4049, SN54HC4050, SN74HC4049, SN74HC4050 HEX INVERTING AND NONINVERTING BUFFERS

D2831, MARCH 1984

- Package Options Include Both Plastic and Ceramic DIPs and Small Outline (SO)
- Dependable Texas Instruments Quality and Reliability

### description

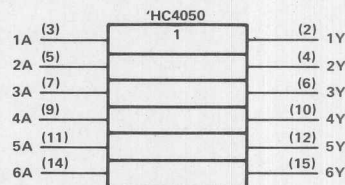
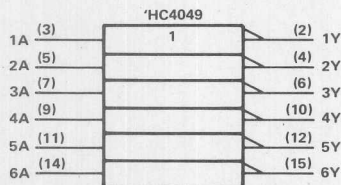
The 'HC4049 and 'HC4050 hex inverting and noninverting buffers may be used as current sinks or source drivers, hex drivers, or high-to-low-logic-level (e.g., CMOS to TTL) converters. Logic-level conversion is accomplished using only one supply voltage ( $V_{CC}$ ). The high-level input signal ( $V_{IH}$ ) can exceed the  $V_{CC}$  supply voltage when this device is used for logic-level conversions.

Pin 16 of the 'HC4049 and 'HC4050 in the J or N package is not internally connected; therefore, any external connection to this pin does not affect circuit operation.

FUNCTION TABLE

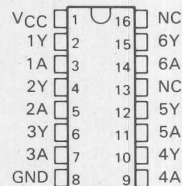
INPUT A	OUTPUT Y	
	'HC4049	'HC4050
H	L	H
L	H	L

### logic symbols



Pin numbers shown are for J and N packages.

SN54HC4049, SN54HC4050 ... J PACKAGE  
SN74HC4049, SN74HC4050 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



NC—No internal connection

Not available in chip carrier package with JEDEC-Standard pin-out. For chip carrier information, contact the factory.

5 PRODUCT PREVIEWS

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## HIGH-SPEED CMOS LOGIC

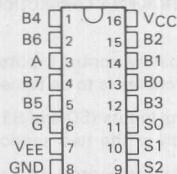
## TYPES SN54HC4051, SN54HC4052, SN54HC4053 SN74HC4051, SN74HC4052, SN74HC4053 ANALOG MULTIPLEXERS/DEMULTIPLEXERS

D2804, MARCH 1984

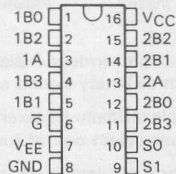
- Fast Switching
- Low Crosstalk Between Switches
- High On/Off Output Voltage Ratio
- Analog Supply Voltage Range  
( $V_{CC} - V_{EE}$ ) ... 3 V to 12 V

- Digital Supply Voltage Range  
( $V_{CC} - GND$ ) ... 2 V to 6 V
- Package Options Include Both Plastic and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

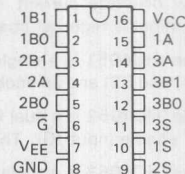
SN54HC4051 ... J PACKAGE  
SN74HC4051 ... J OR N OR D (= SO)  
PACKAGE  
(TOP VIEW)



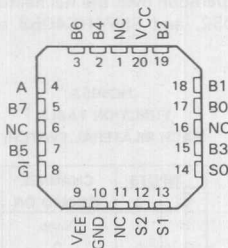
SN54HC4052 ... J PACKAGE  
SN74HC4052 ... J OR N OR D (= SO)  
PACKAGE  
(TOP VIEW)



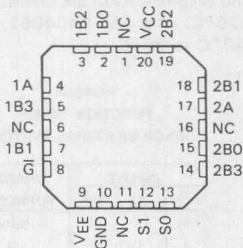
SN54HC4053 ... J PACKAGE  
SN74HC4053 ... J OR N OR D (= SO)  
PACKAGE  
(TOP VIEW)



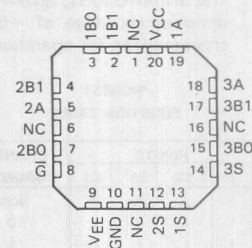
SN54HC4051 ... FH OR FK PACKAGE  
(TOP VIEW)



SN54HC4052 ... FH OR FK PACKAGE  
(TOP VIEW)

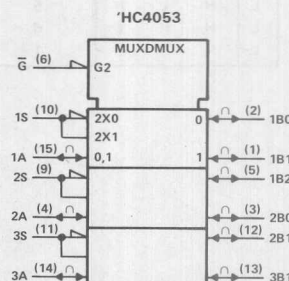
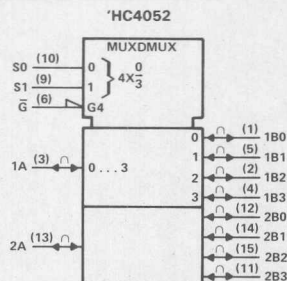
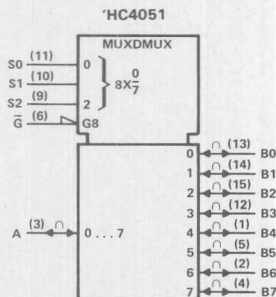


SN54HC4053 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection.

### logic symbols



Pin numbers shown are for J and N packages.

### PRODUCT PREVIEW

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# TYPES SN54HC4051, SN54HC4052, SN54HC4053 SN74HC4051, SN74HC4052, SN74HC4053 ANALOG MULTIPLEXERS/DEMULTIPLEXERS

## description

These devices are analog multiplexers/demultiplexers incorporating built-in level shifting. The level shifting allows a control input range of GND to  $V_{CC}$  for an analog signal range of  $V_{EE}$  to  $V_{CC}$ . Thus the common situation of positive digital signals controlling the multiplexing of both positive and negative analog signals can be accommodated.

These digitally controlled bilateral analog switches have low on-state impedance and very low off-state current. When the inhibit input terminal is high, all channels are off.

The 'HC4051 is a single eight-channel multiplexer/demultiplexer having three binary control inputs ( $S_0$ ,  $S_1$ , and  $S_2$ ) and an enable input ( $\bar{G}$ ). The three binary signals select one of eight channels to be turned on.

The 'HC4052 is a dual four-channel multiplexer/demultiplexer having two control inputs ( $S_0$  and  $S_1$ ) and an enable input ( $\bar{G}$ ). The two binary signals select one of four channels in each of the two sections.

The 'HC4053 is a triple two-channel multiplexer/demultiplexer having three separate control inputs ( $1S$ ,  $2S$ , and  $3S$ ) and a common enable input ( $\bar{G}$ ). Each  $S$  input independently selects one of two channels in one of the three sections.

The SN54HC4051, SN54HC4052, and SN54HC4053 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4051, SN74HC4052, and SN74HC4053 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

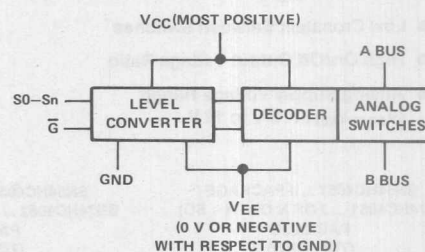


FIGURE 1. INTERNAL POWER SUPPLY CONNECTIONS

'HC4051  
FUNCTION TABLE

$\bar{G}$	INPUTS			CHANNEL TURNED ON
	$S_2$	$S_1$	$S_0$	
H	X	X	X	None
L	L	L	L	0
L	L	L	H	1
L	L	H	L	2
L	L	H	H	3
L	H	L	L	4
L	H	L	H	5
L	H	H	L	6
L	H	H	H	7

'HC4052  
FUNCTION TABLE  
(EACH BILATERAL SWITCH)

$\bar{G}$	INPUTS		CHANNEL TURNED ON
	$S_1$	$S_0$	
H	X	X	None
L	L	L	0
L	L	H	1
L	H	L	2
L	H	H	3

'HC4053  
FUNCTION TABLE  
(EACH BILATERAL SWITCH)

$\bar{G}$	INPUTS		CHANNEL TURNED ON
	$S$		
H	X		None
L	L		0
L	H		1

## HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4316, SN74HC4316 QUAD BILATERAL SWITCHES

D2804, MARCH 1984

- Fast Switching Speeds
- Low Crosstalk Between Switches
- High On/Off Output Voltage Ratio
- Analog Supply Voltage Range  
( $V_{CC} - V_{EE}$ ) ... 3 V to 12 V
- Digital Supply Voltage Range  
( $V_{CC} - GND$ ) ... 2 V to 6 V
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

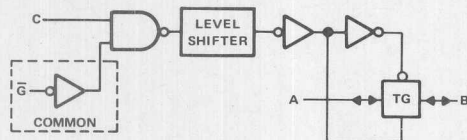
### description

The 'HC4316 is a quadruple bilateral switch. The switches can transmit analog or digital signals in either direction. The 'HC4316 offers high control input impedance and low crosstalk between switches.

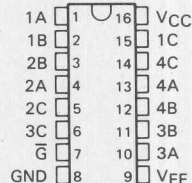
Applications include digital switching and multiplexing analog-to-digital and digital-to-analog conversion; digital control of frequency, impedance, phase and analog-signal gain; and use as a squelch control, chopper, modulator, demodulator, or commutating switch.

The SN54HC4316 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4316 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

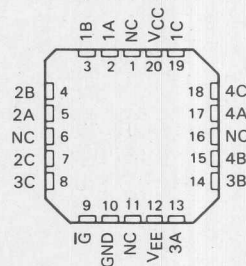
### logic diagram, each switch (positive logic)



SN54HC4316 ... J PACKAGE  
SN74HC4316 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

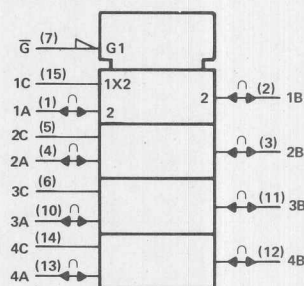


SN54HC4316 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

PRODUCT PREVIEWS

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CMOS LOGIC

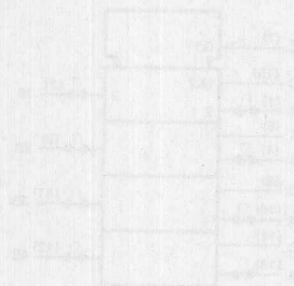
CMOS LOGIC  
CMOS LOGIC  
CMOS LOGIC



CMOS LOGIC  
CMOS LOGIC  
CMOS LOGIC



CMOS LOGIC



CMOS LOGIC

- 1. Low Cost CMOS Logic
- 2. High Speed CMOS Logic
- 3. High Speed CMOS Logic
- 4. High Speed CMOS Logic
- 5. High Speed CMOS Logic
- 6. High Speed CMOS Logic
- 7. High Speed CMOS Logic
- 8. High Speed CMOS Logic
- 9. High Speed CMOS Logic
- 10. High Speed CMOS Logic
- 11. High Speed CMOS Logic
- 12. High Speed CMOS Logic
- 13. High Speed CMOS Logic
- 14. High Speed CMOS Logic
- 15. High Speed CMOS Logic
- 16. High Speed CMOS Logic

The CMOS logic family is a family of digital logic circuits that use complementary metal-oxide-semiconductor (CMOS) technology. It is characterized by its low power consumption and high speed. The CMOS logic family is used in a wide range of applications, including digital logic, memory, and microprocessors. The CMOS logic family is also known for its high reliability and long life expectancy.





# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4511, SN74HC4511 BCD-TO-SEVEN-SEGMENT DECODERS/DRIVERS WITH LATCHED INPUTS

D2684, DECEMBER 1982—REVISED MARCH 1984

- Latch Storage of Code
- Blanking Input
- Lamp Test Provision
- Readout Blanking on All Illegal Input Combinations
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

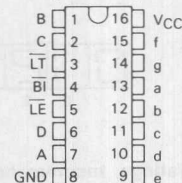
The 'HC4511 provides the functions of a 4-bit storage latch, a BCD-to-seven-segment decoder, and an output driver. Lamp test (LT), blanking (BI), and latch enable (LE) inputs are used to test the display, to turn off or pulse-modulate the brightness of the display, and to store a BCD code, respectively.

The SN54HC4511 is characterized for operation over the full military temperature range of -55°C to 125°C. The SN74HC4511 is characterized for operation from -40°C to 85°C.

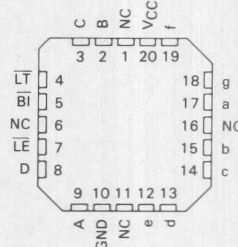
FUNCTION TABLE

INPUTS				OUTPUTS							DISPLAY
LE	BI	LT	D	C	B	A	a	b	c	d	
L	H	H	L	L	L	L	H	H	H	H	0
L	H	H	L	L	L	H	L	H	H	L	1
L	H	H	L	L	H	L	H	H	L	H	2
L	H	H	L	L	H	H	H	H	H	L	3
L	H	H	L	H	L	L	L	H	H	L	4
L	H	H	L	H	L	H	H	L	H	H	5
L	H	H	L	H	H	L	L	H	H	H	6
L	H	H	L	H	H	H	H	H	L	L	7
L	H	H	H	L	L	L	H	H	H	H	8
L	H	H	H	L	L	H	H	H	L	L	9
L	H	H	H	L	H	H	L	L	L	L	Blank
L	H	H	H	L	H	H	L	L	L	L	Blank
L	H	H	H	H	L	L	L	L	L	L	Blank
L	H	H	H	H	H	L	L	L	L	L	Blank
L	H	H	H	H	H	H	L	L	L	L	Blank
L	H	H	H	H	H	H	L	L	L	L	Blank
X	X	L	X	X	X	X	H	H	H	H	8
X	L	H	X	X	X	X	L	L	L	L	Blank
H	H	H	X	X	X	X	All outputs remain in state existing before LE↑				

SN54HC4511 ... J PACKAGE  
SN74HC4511 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)

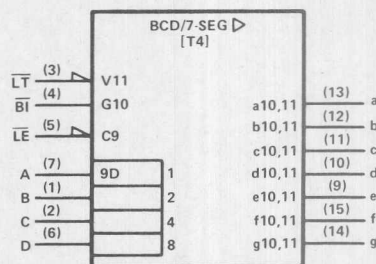


SN54HC4511 ... FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

### logic symbol



Pin numbers shown are for J and N packages.

### PRODUCT PREVIEW

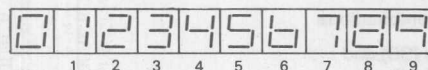
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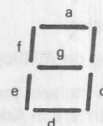
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**TYPES SN54HC4511, SN74HC4511**  
**BCD-TO-SEVEN-SEGMENT DECODERS/DRIVERS WITH LATCHED INPUTS**

**FONT TABLE T4 —**  
**RESULTANT DISPLAYS USING 'HC4511**



**SEGMENT IDENTIFICATION**



maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

PRODUCT PREVIEWS

5

# HIGH-SPEED CMOS LOGIC

## TYPES SN54HC4514, SN54HC4515, SN74HC4514, SN74HC4515 4-LINE TO 16-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES

D2684, DECEMBER 1982 - REVISED MARCH 1984

- Two Output Options:  
'HC4514 Has Active-High Outputs  
'HC4515 Has Active-Low Outputs
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

### description

These devices present two output options of a 4-line to 16-line decoder with latched inputs. The 'HC4514 presents a high level at the selected output. The 'HC4515 presents a low level at the selected output.

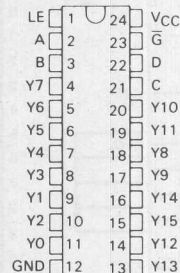
These devices consist of four storage latches with common latch enable (LE) and inhibit ( $\bar{G}$ ) inputs. When a low signal is applied to the LE input, the input data is stored, decoded, and presented to the output. When  $\bar{G}$  is high, all sixteen 'HC4514 outputs are at a low logic level, or all 'HC4515 outputs are at a high logic level.

The SN54HC4514 and the SN54HC4515 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC4514 and SN74HC4515 are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

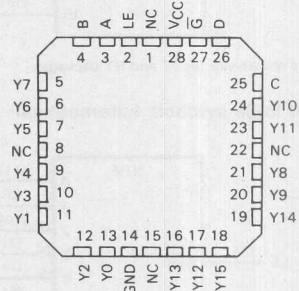
FUNCTION TABLE

INPUTS						OUTPUT SELECTED	OUTPUTS	
LE	$\bar{G}$	D	C	B	A		'HC4514	'HC4515
H	L	L	L	L	L	0		
H	L	L	L	L	H	1		
H	L	L	L	H	L	2		
H	L	L	L	H	H	3		
H	L	L	H	L	L	4		
H	L	L	H	L	H	5	Selected	Selected
H	L	L	H	H	L	6	Output = H	Output = L
H	L	L	H	H	H	7	All others = L	All others = H
H	L	H	L	L	L	8		
H	L	H	L	L	H	9		
H	L	H	L	H	L	10		
H	L	H	L	H	H	11		
H	L	H	H	L	L	12		
H	L	H	H	L	H	13		
H	L	H	H	H	L	14		
H	L	H	H	H	H	15		
X	H	X	X	X	X		All = L	All = H
L	L	X	X	X	X	All outputs remain in state existing before LEI		

SN54HC'...JT PACKAGE  
SN74HC'...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC'...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

5 PRODUCT PREVIEWS

### PRODUCT PREVIEW

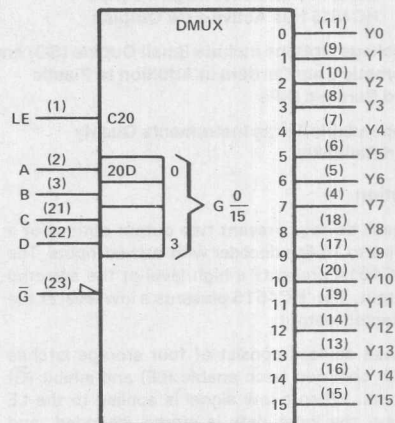
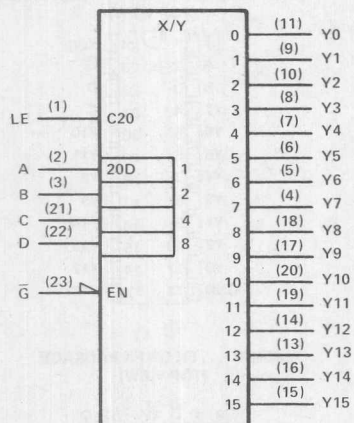
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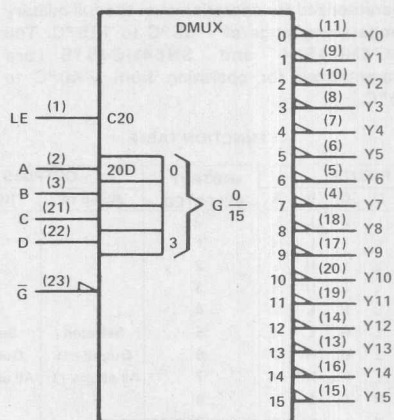
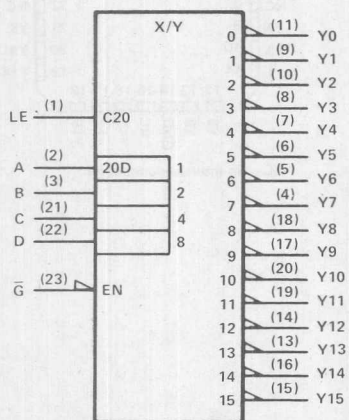
**TYPES SN54HC4514, SN54HC4515, SN74HC4514, SN74HC4515**  
**4-LINE TO 16-LINE DECODERS/DEMULTIPLEXERS**  
**WITH ADDRESS LATCHES**

**'HC4514 logic symbols (alternatives)**



Pin numbers shown are for JT and NT packages.

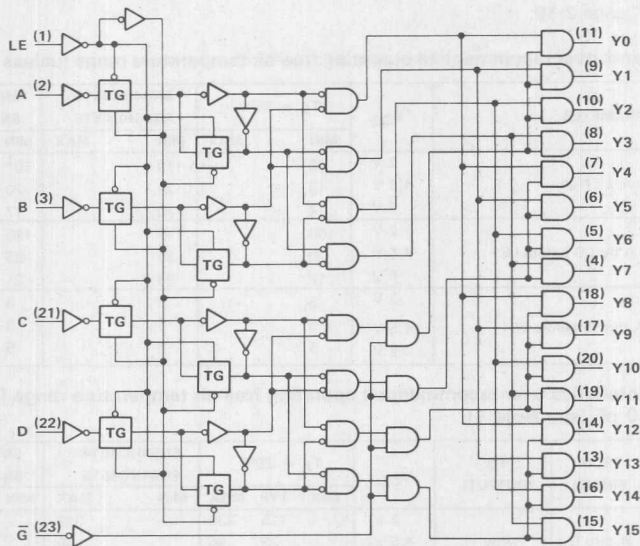
**'HC4515 logic symbols (alternatives)**



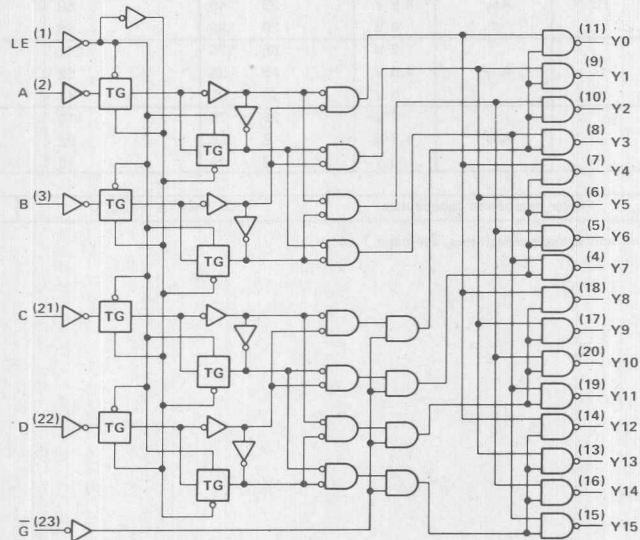
Pin numbers shown are for JT and NT packages.

## 4-LINE TO 16-LINE DECODERS/DEMULTIPLEXERS WITH ADDRESS LATCHES

'HC4514 logic diagram (positive logic)



### 'HC4515 logic diagram (positive logic)



Pin numbers shown are for JT and NT packages.

## PRODUCT PREVIEWS

5

**TYPES SN54HC4514, SN54HC4515, SN74HC4514, SN74HC4515**  
**4-LINE TO 16-LINE DECODERS/DEMULTIPLEXERS**  
**WITH ADDRESS LATCHES**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table IV, page 2-10.

timing requirements over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	V <sub>CC</sub>	T <sub>A</sub> = 25°C		SN54HC4514 SN54HC4515		SN74HC4514 SN74HC4515		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t <sub>w</sub> Pulse duration, LE high	2 V	80		119		101		ns
	4.5 V	16		24		20		
	6 V	14		20		17		
t <sub>su</sub> Setup time, A thru D before LE ↓	2 V	100		149		126		ns
	4.5 V	20		30		25		
	6 V	17		25		21		
t <sub>h</sub> Hold time, A thru D before LE ↓	2 V	5		5		5		ns
	4.5 V	5		5		5		
	6 V	5		5		5		

switching characteristics over recommended operating free-air temperature range (unless otherwise noted), C<sub>L</sub> = 50 pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub>	T <sub>A</sub> = 25°C			SN54HC4514 SN54HC4515		SN74HC4514 SN74HC4515		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
t <sub>pd</sub>	A thru D	Any	2 V		115	230		343		290	ns
			4.5 V		23	46		69		58	
			6 V		20	39		58		49	
t <sub>pd</sub>	LE	Any	2 V		115	230		343		290	ns
			4.5 V		23	46		69		58	
			6 V		20	39		58		49	
t <sub>pd</sub>	$\overline{G}$	Any	2 V		88	175		261		221	ns
			4.5 V		18	35		52		44	
			6 V		15	30		44		37	
t <sub>t</sub>		Any	2 V		38	75		110		95	ns
			4.5 V		8	15		22		19	
			6 V		6	13		19		16	

C <sub>pd</sub>	Power dissipation capacitance	No load, T <sub>A</sub> = 25°C	60 pF typ
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NOTE 1: For load circuit and voltage waveforms, see page 1-14.



- Operation from Very Slow Transitions
- Temperature-Compensated Threshold Levels
- High Noise Immunity
- Same Pinouts as 'HC08
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

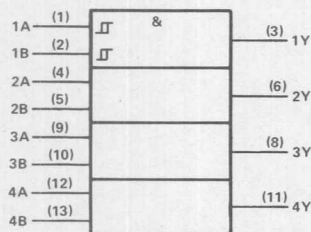
# description

Each circuit functions as a quadruple AND gate. They perform the Boolean function  $Y = A \cdot B$  or  $Y = \overline{A} + \overline{B}$  in positive logic. However, because of the Schmitt action, the inputs have different input threshold levels for positive- and negative-going signals.

The circuits are temperature compensated and can be triggered from the slowest of input ramps and will still give clean jitter-free output signals.

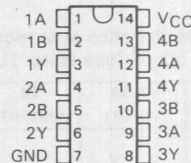
The SN54HC7001 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7001 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

# logic symbol

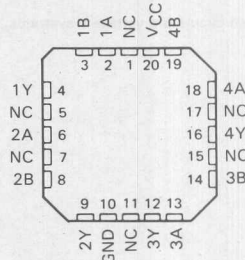


Pin numbers shown are for J and N packages.

SN54HC7001 ... J PACKAGE  
SN74HC7001 ... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7001 ... FH OR FK PACKAGE  
(TOP VIEW)

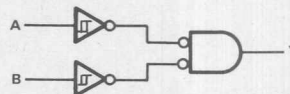


NC—No internal connection

FUNCTION TABLE  
(each gate)

INPUTS		OUTPUT
A	B	Y
H	H	H
L	X	L
X	L	L

logic diagram, each gate (positive logic)



# PRODUCT PREVIEW

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# **TYPES SN54HC7001, SN74HC7001** **QUADRUPLER POSITIVE-AND GATES WITH SCHMITT-TRIGGER INPUTS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ C$			SN54HC7001		SN74HC7001		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40						ns
			4.5 V		13						
			6 V		11						
$t_t$		Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

PRODUCT PREVIEWS

5



- Operation from Very Slow Transitions
- Temperature-Compensated Threshold Levels
- High Noise Immunity
- Same Pinouts as 'HC36
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

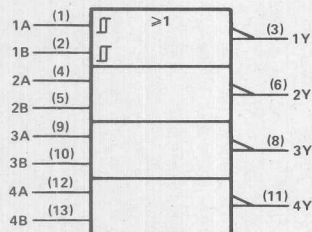
### description

Each circuit functions as a quadruple NOR gate. They perform the Boolean function  $Y = A + B$  or  $Y = \overline{A \cdot B}$  in positive logic. However, because of the Schmitt action, the inputs have different input threshold levels for positive- and negative-going signals.

The circuits are temperature compensated and can be triggered from the slowest of input ramps and will still give clean jitter-free output signals.

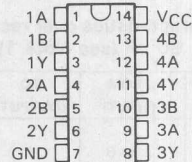
The SN54HC7002 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7002 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### logic symbol

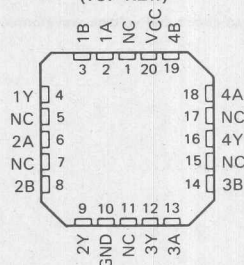


Pin numbers shown are for J and N packages.

SN54HC7002... J PACKAGE  
SN74HC7002... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7002... FH OR FK PACKAGE  
(TOP VIEW)

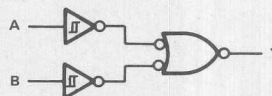


NC—No internal connection

FUNCTION TABLE

INPUTS		OUTPUT
A	B	Y
H	X	L
X	H	L
L	L	H

logic diagram, each gate (positive logic)



### PRODUCT PREVIEW

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# TYPES SN54HC7002, SN74HC7002 QUADRUPLE POSITIVE-NOR GATES WITH SCHMITT-TRIGGER INPUTS

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC7002		SN74HC7002		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V			40					ns
			4.5 V			13					
			6 V			11					
$t_t$		Any	2 V			28					ns
			4.5 V			8					
			6 V			6					

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

PRODUCT PREVIEWS

5

# **HIGH-SPEED CMOS LOGIC**

## **TYPES SN54HC7003, SN74HC7003 QUADRUPLE POSITIVE-NAND GATES WITH SCHMITT-TRIGGER INPUTS AND OPEN-DRAIN OUTPUTS**

D2831, MARCH 1984

- Operation from Very Slow Transitions
- Temperature-Compensated Threshold Levels
- High Noise Immunity
- Same Pinouts as 'HC03
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

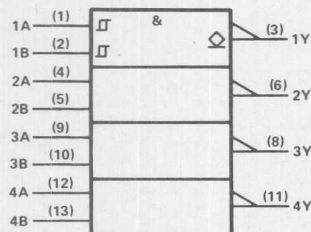
### **description**

Each circuit functions as a quadruple NAND gate. They perform the Boolean function  $Y = \overline{A \cdot B}$  or  $Y = \overline{A + B}$  in positive logic. However, because of the Schmitt action, the inputs have different input threshold levels for positive- and negative-going signals.

The circuits are temperature compensated and can be triggered from the slowest of input ramps and will still give clean jitter-free output signals.

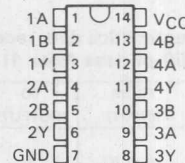
The SN54HC7003 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7003 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

### **logic symbol**

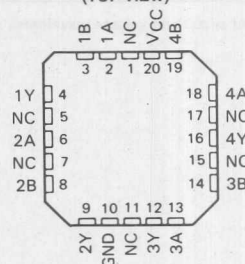


Pin numbers shown are for J and N packages.

SN54HC7003... J PACKAGE  
SN74HC7003... J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7003... FH OR FK PACKAGE  
(TOP VIEW)

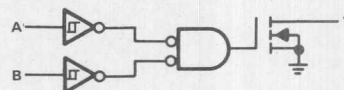


NC—No internal connection

**FUNCTION TABLE (each gate)**

INPUTS		OUTPUT
A	B	Y
H	H	L
L	X	H
X	L	H

**logic diagram, each gate (positive logic)**



PRODUCT PREVIEWS

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### **PRODUCT PREVIEW**

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# **TYPES SN54HC7003, SN74HC7003** **QUADRUPLER POSITIVE-NAND GATES WITH SCHMITT-TRIGGER INPUTS** **AND OPEN-DRAIN OUTPUTS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table 1, page 2-4.

switching characteristics over recommended operating free-air temperature range (unless otherwise noted),  $C_L = 50$  pF (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC7003		SN74HC7003		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40						ns
			4.5 V		13						
			6 V		11						
$t_t$	Any	Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

PRODUCT PREVIEWS

5



# **HIGH-SPEED CMOS LOGIC**

# **TYPES SN54HC7006, SN74HC7006 6-SECTION MULTIFUNCTION (NAND, INVERT, NOR) CIRCUITS**

D2831, MARCH 1984

- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

## **description**

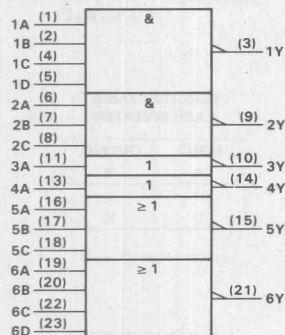
The SN54HC7006 and SN74HC7006 are each comprised of the following sections:

- One 3-input NAND gate
- One 4-input NAND gate
- One 3-input NOR gate
- One 4-input NOR gate
- Two inverters

They perform the Boolean functions shown under each function table.

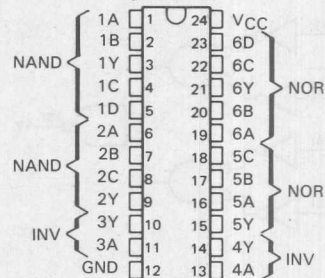
The SN54HC7006 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7006 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

## **logic symbol**

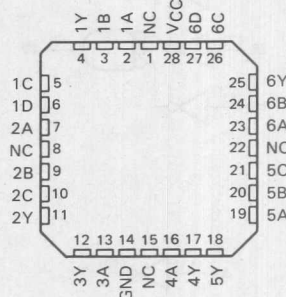


Pin numbers shown are for JT and NT packages.

SN54HC7006...JT PACKAGE  
SN74HC7006...JT OR NT OR D (= SO) PACKAGE  
(TOP VIEW)



SN54HC7006...FH OR FK PACKAGE  
(TOP VIEW)



NC—No internal connection

5 PRODUCT PREVIEWS

## **PRODUCT PREVIEW**

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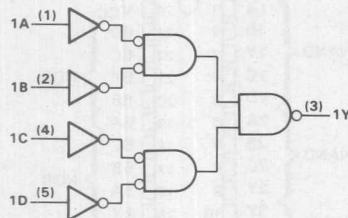


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**TYPES SN54HC7006, SN74HC7006**  
**6-SECTION MULTIFUNCTION (NAND, INVERT, NOR) CIRCUITS**

logic diagrams (positive logic)

**4-INPUT NAND GATE**

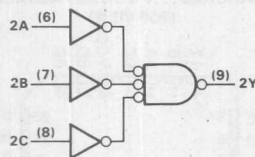


FUNCTION TABLE

INPUTS				OUTPUT
A	B	C	D	Y
H	H	H	H	L
L	X	X	X	H
X	L	X	X	H
X	X	L	X	H
X	X	X	L	H

positive logic:  $Y = \overline{A \cdot B \cdot C \cdot D}$  or  
 $Y = \overline{A} + \overline{B} + \overline{C} + \overline{D}$

**3-INPUT NAND GATE**



FUNCTION TABLE

INPUTS			OUTPUT
A	B	C	Y
H	H	H	L
L	X	X	H
X	L	X	H
X	X	L	H

positive logic:  $Y = \overline{A \cdot B \cdot C}$  or  
 $Y = \overline{A} + \overline{B} + \overline{C}$

**INVERTERS**

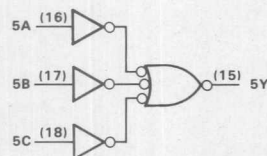


FUNCTION TABLE  
(EACH INVERTER)

INPUT	OUTPUT
A	Y
H	L
L	H

positive logic:  $Y = \overline{A}$

**3-INPUT NOR GATE**



FUNCTION TABLE

INPUTS			OUTPUT
A	B	C	Y
H	X	X	L
X	H	X	L
X	X	H	L
L	L	L	H

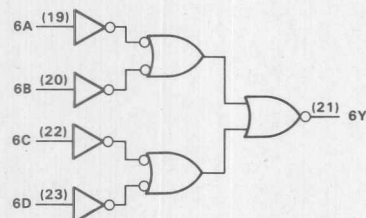
positive logic:  $Y = \overline{A + B + C}$  or  
 $Y = \overline{A} \cdot \overline{B} \cdot \overline{C}$

Pin numbers shown are for JT and NT packages.

**TYPES SN54HC7006, SN74HC7006**  
**6-SECTION MULTIFUNCTION (NAND, INVERT, NOR) CIRCUITS**

logic diagram (positive logic)

**4-INPUT NOR GATE**



**FUNCTION TABLE**

INPUTS				OUTPUT
A	B	C	D	Y
H	X	X	X	L
X	H	X	X	L
X	X	H	X	L
X	X	X	H	L
L	L	L	L	H

positive logic:  $Y = \overline{A+B+C+D}$  or  
 $Y = \overline{A} \cdot \overline{B} \cdot \overline{C} \cdot \overline{D}$

Pin numbers shown are for JT and NT packages.

**absolute maximum ratings, recommended operating conditions, electrical characteristics**

See Table I, page 2-4.

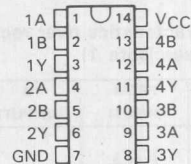
**5 PRODUCT PREVIEWS**

**5**



- Operation from Very Slow Transitions
- Temperature-Compensated Threshold Levels
- High Noise Immunity
- Same Pinouts as 'HC32
- Package Options Include Small Outline (SO) and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54HC7032...J PACKAGE  
SN74HC7032...J OR N OR D (= SO) PACKAGE  
(TOP VIEW)



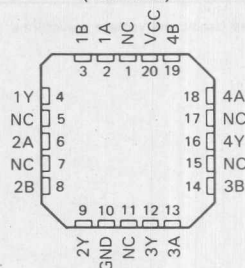
### description

Each circuit functions as a quadruple OR gate. They perform the Boolean function  $Y = A + B$  or  $Y = \overline{A} \cdot \overline{B}$  in positive logic. However, because of the Schmitt action, the inputs have different input threshold levels for positive- and negative-going signals.

The circuits are temperature compensated and can be triggered from the slowest of input ramps and will still give clean jitter-free output signals.

The SN54HC7032 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74HC7032 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

SN54HC7032...FH OR FK PACKAGE  
(TOP VIEW)

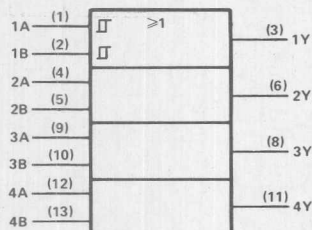


NC—No internal connection

FUNCTION TABLE

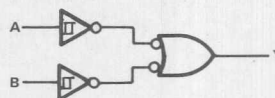
INPUTS		OUTPUT
A	B	Y
H	X	H
X	H	H
L	L	L

### logic symbol



Pin numbers shown are for J and N packages.

### logic diagram, each gate (positive logic)



### PRODUCT PREVIEW

This document contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

# **TYPES SN54HC7032, SN74HC7032** **QUADRUPLER POSITIVE-OR GATES WITH SCHMITT-TRIGGER INPUTS**

absolute maximum ratings, recommended operating conditions, and electrical characteristics

See Table I, page 2-6.

switching characteristics over recommended free-air temperature range (unless otherwise noted),  
 $C_L = 50 \text{ pF}$  (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC}$	$T_A = 25^\circ\text{C}$			SN54HC7032		SN74HC7032		UNIT
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$t_{pd}$	A or B	Y	2 V		40						ns
			4.5 V		13						
			6 V		11						
$t_t$	Any	Any	2 V		28						ns
			4.5 V		8						
			6 V		6						

NOTE 1: For load circuit and voltage waveforms, see page 1-14.

PRODUCT PREVIEWS

5



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## EXPLANATION OF LOGIC SYMBOLS



# Explanation of Logic Symbols

F. A. Mann

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IEEE Standards may be purchased from:

Institute of Electrical and Electronics Engineers, Inc.  
IEEE Standards Office  
345 East 47th Street  
New York, N.Y. 10017

International Electrotechnical Commission (IEC)  
publications may be purchased from:

American National Standards Institute, Inc.  
1430 Broadway  
New York, N.Y. 10018

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## 1.0 INTRODUCTION

The International Electrotechnical Commission (IEC) has been developing a very powerful symbolic language that can show the relationship of each input of a digital logic circuit to each output without showing explicitly the internal logic. At the heart of the system is dependency notation, which will be explained in Section 4.

The system was introduced in the USA in a rudimentary form in IEEE/ANSI Standard Y32.14-1973. Lacking at that time a complete development of dependency notation, it offered little more than a substitution of rectangular shapes for the familiar distinctive shapes for representing the basic functions of AND, OR, negation, etc. This is no longer the case.

Internationally, Working Group 2 of IEC Technical Committee TC-3 has prepared a new document (Publication 617-12) that consolidates the original work started in the mid 1960's and published in 1972 (Publication 117-15) and the amendments and supplements that have followed. Similarly for the USA, IEEE Committee SCC 11.9 has revised the publication IEEE Std 91/ANSI Y32.14. Now numbered simply IEEE Std 91-1984, the IEEE standard contains all of the IEC work that has been approved, and also a small amount of material still under international consideration. Texas Instruments is participating in the work of both organizations and this document introduces new logic symbols in accordance with the new standards. When changes are made as the standards develop, future editions will take those changes into account.

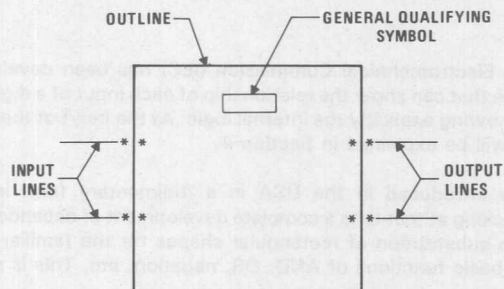
The following explanation of the new symbolic language is necessarily brief and greatly condensed from what the standards publications will contain. This is not intended to be sufficient for those people who will be developing symbols for new devices. It is primarily intended to make possible the understanding of the symbols used in various data books and the comparison of the symbols with logic diagrams, functional block diagrams, and/or function tables will further help that understanding.

## 2.0 SYMBOL COMPOSITION

A symbol comprises an outline or a combination of outlines together with one or more qualifying symbols. The shape of the symbols is not significant. As shown in Figure 1, general qualifying symbols are used to tell exactly what logical operation is performed by the elements. Table I shows general qualifying symbols defined in the new standards. Input lines are placed on the left and output lines are placed on the right. When an exception is made to that convention, the direction of signal flow is indicated by an arrow as shown in Figure 11.

All outputs of a single, unsubdivided element always have identical internal logic states determined by the function of the element except when otherwise indicated by an associated qualifying symbol or label inside the element.





\*Possible positions for qualifying symbols relating to inputs and outputs

Figure 1. Symbol Composition

The outlines of elements may be abutted or embedded in which case the following conventions apply. There is no logic connection between the elements when the line common to their outlines is in the direction of signal flow. There is at least one logic connection between the elements when the line common to their outlines is perpendicular to the direction of signal flow. The number of logic connections between elements will be clarified by the use of qualifying symbols and this is discussed further under that topic. If no indications are shown on either side of the common line, it is assumed there is only one connection.

When a circuit has one or more inputs that are common to more than one element of the circuit, the common-control block may be used. This is the only distinctively shaped outline used in the IEC system. Figure 2 shows that unless otherwise qualified by dependency notation, an input to the common-control block is an input to each of the elements below the common-control block.

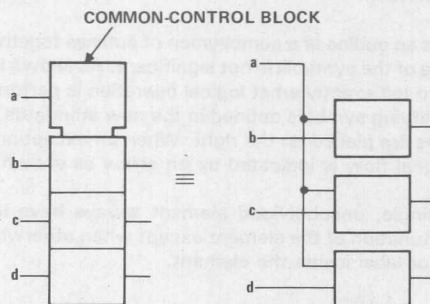


Figure 2. Common-Control Block



A common output depending on all elements of the array can be shown as the output of a common-output element. Its distinctive visual feature is the double line at its top. In addition the common-output element may have other inputs as shown in Figure 3. The function of the common-output element must be shown by use of a general qualifying symbol.

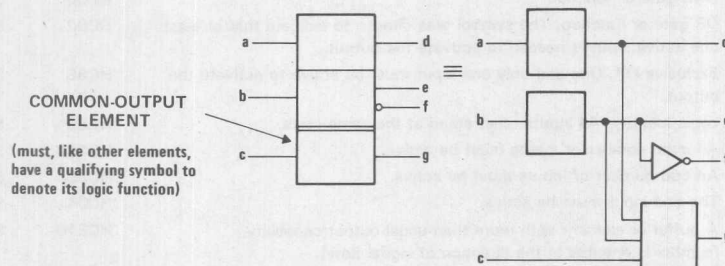


Figure 3. Common-Output Element

### 3.0 QUALIFYING SYMBOLS

#### 3.1 General Qualifying Symbols








Table I shows general qualifying symbols defined by IEEE Standard 91. These characters are placed near the top center or the geometric center of a symbol or symbol element to define the basic function of the device represented by the symbol or of the element.

#### 3.2 Qualifying Symbols for Inputs and Outputs

Qualifying symbols for inputs and outputs are shown in Table II and will be familiar to most users with the possible exception of the logic polarity and analog signal indicators. The older logic negation indicator means that the external 0 state produces the internal 1 state. The internal 1 state means the active state. Logic negation may be used in pure logic diagrams; in order to tie the external 1 and 0 logic states to the levels H (high) and L (low), a statement of whether positive logic (1 = H, 0 = L) or negative logic (1 = L, 0 = H) is being used is required or must be assumed. Logic polarity indicators eliminate the need for calling out the logic convention and are used in various data books in the symbology for actual devices. The presence of the triangular polarity indicator indicates that the L logic level will produce the internal 1 state (the active state) or that, in the case of an output, the internal 1 state will produce the external L level. Note how the active direction of transition for a dynamic input is indicated in positive logic, negative logic, and with polarity indication.

The internal connections between logic elements abutted together in a symbol may be indicated by the symbols shown in Table II. Each logic connection may be shown by the presence of qualifying symbols at one or both sides of the common line and if confusion can arise about the numbers of connections, use can be made of one of the internal connection symbols.

Table I. General Qualifying Symbols

SYMBOL	DESCRIPTION	CMOS EXAMPLE	TTL EXAMPLE
&	AND gate or function.	'HC00	SN7400
$\geq 1$	OR gate or function. The symbol was chosen to indicate that at least one active input is needed to activate the output.	'HC02	SN7402
= 1	Exclusive OR. One and only one input must be active to activate the output.	'HC86	SN7486
=	Logic identity. All inputs must stand at the same state.	'HC86	SN74180
2k	An even number of inputs must be active.	'HC280	SN74180
2k + 1	An odd number of inputs must be active.	'HC86	SN74ALS86
1	The one input must be active.	'HC04	SN7404
	A buffer or element with more than usual output capability (symbol is oriented in the direction of signal flow).	'HC240	SN74S436
	Schmitt trigger; element with hysteresis.	'HC132	SN74LS18
X/Y	Coder, code converter (DEC/BCD, BIN/OUT, BIN/7-SEG, etc.).	'HC42	SN74LS347
MUX	Multiplexer/data selector.	'HC151	SN74150
DMUX or DX	Demultiplexer.	'HC138	SN74138
$\Sigma$	Adder.	'HC283	SN74LS385
P-Q	Subtractor.	*	SN74LS385
CPG	Look-ahead carry generator	'HC182	SN74182
$\pi$	Multiplier.	*	SN74LS384
COMP	Magnitude comparator.	'HC85	SN74LS682
ALU	Arithmetic logic unit.	'HC181	SN74LS381
	Retriggerable monostable.	'HC123	SN74LS422
1 	Nonretriggerable monostable (one-shot)	'HC221	SN74121
	Astable element. Showing waveform is optional.	*	SN74LS320
	Synchronously starting astable.	*	SN74LS624
	Astable element that stops with a completed pulse.	*	*
SRGm	Shift register. m = number of bits.	'HC164	SN74LS595
CTRm	Counter. m = number of bits; cycle length = $2^m$ .	'HC590	SN54LS590
CTR DIVm	Counter with cycle length = m.	'HC160	SN74LS668
RCTRm	Asynchronous (ripple-carry) counter; cycle length = $2^m$ .	'HC4020	*
ROM	Read-only memory.	*	SN74187
RAM	Random-access read/write memory.	'HC189	SN74170
FIFO	First-in, first-out memory.	*	SN74LS222
l = 0	Element powers up cleared to 0 state.	*	SN74AS877
l = 1	Element powers up set to 1 state.	'HC7022	SN74AS877
$\Phi$	Highly complex function; "gray box" symbol with limited detail shown under special rules.	*	SN74LS608

\*Not all of the general qualifying symbols have been used in TI's CMOS and TTL data books, but they are included here for the sake of completeness.

Table II. Qualifying Symbols for Inputs and Outputs

	Logic negation at input. External 0 produces internal 1.
	Logic negation at output. Internal 1 produces external 0.
	Active-low input. Equivalent to  in positive logic.
	Active-low output. Equivalent to  in positive logic.
	Active-low input in the case of right-to-left signal flow.
	Active-low output in the case of right-to-left signal flow.
	Signal flow from right to left. If not otherwise indicated, signal flow is from left to right.
	Bidirectional signal flow.

	POSITIVE LOGIC	NEGATIVE LOGIC	POLARITY INDICATION
	1	1	not used
	not used	not used	H
	0	0	L
	Nonlogic connection. A label inside the symbol will usually define the nature of this pin.		
	Input for analog signals (on a digital symbol) (see Figure 14).		
	Input for digital signals (on an analog symbol) (see Figure 14).		
	Internal connection. 1 state on left produces 1 state on right.		
	Negated internal connection. 1 state on left produces 0 state on right.		
	Dynamic internal connection. Transition from 0 to 1 on left produces transitory 1 state on right.		
	Internal input (virtual input). It always stands at its internal 1 state unless affected by an overriding dependency relationship.		
	Internal output (virtual output). Its effect on an internal input to which it is connected is indicated by dependency notation.		

The internal (virtual) input is an input originating somewhere else in the circuit and is not connected directly to a terminal. The internal (virtual) output is likewise not connected directly to a terminal. The application of internal inputs and outputs requires an understanding of dependency notation, which is explained in Section 4.

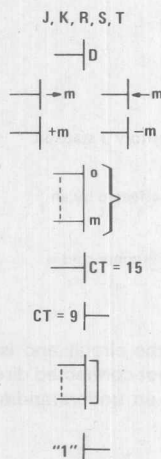
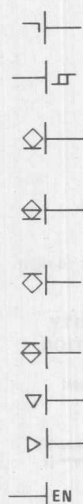


Table III. Symbols Inside the Outline

Postponed output (of a pulse-triggered flip-flop). The output changes when input initiating change (e.g., a C input) returns to its initial external state or level. See § 5.

Bi-threshold input (input with hysteresis).

N-P-N open-collector or similar output that can supply a relatively low-impedance L level when not turned off. Requires external pull-up. Capable of positive-logic wired-AND connection.

Passive-pull-up output is similar to N-P-N open-collector output but is supplemented with a built-in passive pull-up.

N-P-N open-emitter or similar output that can supply a relatively low-impedance H level when not turned off. Requires external pull-down. Capable of positive-logic wired-OR connection.

Passive-pull-down output is similar to N-P-N open-emitter output but is supplemented with a built-in passive pull-down.

3-state output.

Output with more than usual output capability (symbol is oriented in the direction of signal flow).

Enable input

When at its internal 1-state, all outputs are enabled.

When at its internal 0-state, open-collector and open-emitter outputs are off, three-state outputs are in the high-impedance state, and all other outputs (e.g., totem-poles) are at the internal 0-state.

Usual meanings associated with flip-flops (e.g., R = reset, T = toggle)

Data input to a storage element equivalent to:



Shift right (left) inputs,  $m = 1, 2, 3$ , etc. If  $m = 1$ , it is usually not shown.

Counting up (down) inputs,  $m = 1, 2, 3$ , etc. If  $m = 1$ , it is usually not shown.

Binary grouping.  $m$  is highest power of 2.

The contents-setting input, when active, causes the content of a register to take on the indicated value.

The content output is active if the content of the register is as indicated.

Input line grouping . . . indicates two or more terminals used to implement a single logic input.

e.g., The paired expander inputs of SN7450.



Fixed-state output always stands at its internal 1 state. For example, see SN74185.



In an array of elements, if the same general qualifying symbol and the same qualifying symbols associated with inputs and outputs would appear inside each of the elements of the array, these qualifying symbols are usually shown only in the first element. This is done to reduce clutter and to save time in recognition. Similarly, large identical elements that are subdivided into smaller elements may each be represented by an unsubdivided outline. The SN54HC242 or SN54LS440 symbol illustrates this principle.

### 3.3 Symbols Inside the Outline

Table III shows some symbols used inside the outline. Note particularly that open-collector (open-drain), open-emitter (open-source), and three-state outputs have distinctive symbols. An EN input affects all the external outputs of the element in which it is placed, plus the external outputs of any elements shown to be influenced by that element. It has no effect on inputs. When an enable input affects only certain outputs, affects outputs located outside the indicated influence of the element in which the enable input is placed, and/or affects one or more inputs, a form of dependency notation will indicate this (see 4.10). The effects of the EN input on the various types of outputs are shown.

It is particularly important to note that a D input is always the data input of a storage element. At its internal 1 state, the D input sets the storage element to its 1 state, and at its internal 0 state it resets the storage element to its 0 state.

The binary grouping symbol will be explained more fully in Section 8. Binary-weighted inputs are arranged in order and the binary weights of the least-significant and the most-significant lines are indicated by numbers. In this document weights of input and output lines will be represented by powers of two usually only when the binary grouping symbol is used, otherwise decimal numbers will be used. The grouped inputs generate an internal number on which a mathematical function can be performed or that can be an identifying number for dependency notation (Figure 28). A frequent use is in addresses for memories.

Reversed in direction, the binary grouping symbol can be used with outputs. The concept is analogous to that for the inputs and the weighted outputs will indicate the internal number assumed to be developed within the circuit.

Other symbols are used inside the outlines in accordance with the IEC/IEEE standards but are not shown here. Generally these are associated with arithmetic operations and are self-explanatory.

When nonstandardized information is shown inside an outline, it is usually enclosed in square brackets [like these].

## 4.0 DEPENDENCY NOTATION

### 4.1 General Explanation

Dependency notation is the powerful tool that sets the IEC symbols apart from previous systems and makes compact, meaningful, symbols possible. It provides the means of denoting the relationship between inputs, outputs, or inputs and outputs without actually showing all the



elements and interconnections involved. The information provided by dependency notation supplements that provided by the qualifying symbols for an element's function.

In the convention for the dependency notation, use will be made of the terms "affecting" and "affected." In cases where it is not evident which inputs must be considered as being the affecting or the affected ones (e.g., if they stand in an AND relationship), the choice may be made in any convenient way.

So far, eleven types of dependency have been defined and all of these are used in various TI data books. X dependency is used mainly with CMOS circuits. They are listed below in the order in which they are presented and are summarized in Table IV following 4.12.

Section	Dependency Type or Other Subject
4.2	G, AND
4.3	General Rules for Dependency Notation
4.4	V, OR
4.5	N, Negate (Exclusive-OR)
4.6	Z, Interconnection
4.7	X, Transmission
4.8	C, Control
4.9	S, Set and R, Reset
4.10	EN, Enable
4.11	M, Mode
4.12	A, Address

#### 4.2 G (AND) Dependency

A common relationship between two signals is to have them ANDed together. This has traditionally been shown by explicitly drawing an AND gate with the signals connected to the inputs of the gate. The 1972 IEC publication and the 1973 IEEE/ANSI standard showed several ways to show this AND relationship using dependency notation. While ten other forms of dependency have since been defined, the ways to invoke AND dependency are now reduced to one.

In Figure 4 input **b** is ANDed with input **a** and the complement of **b** is ANDed with **c**. The letter **G** has been chosen to indicate AND relationships and is placed at input **b**, inside the symbol. A number considered appropriate by the symbol designer (1 has been used here) is placed after the letter **G** and also at each affected input. Note the bar over the 1 at input **c**.

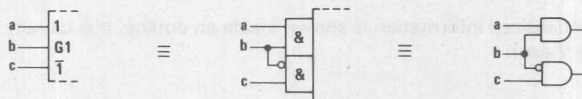


Figure 4. G Dependency Between Inputs

In Figure 5, output **b** affects input **a** with an AND relationship. The lower example shows that it is the internal logic state of **b**, unaffected by the negation sign, that is ANDed. Figure 6 shows input **a** to be ANDed with a dynamic input **b**.



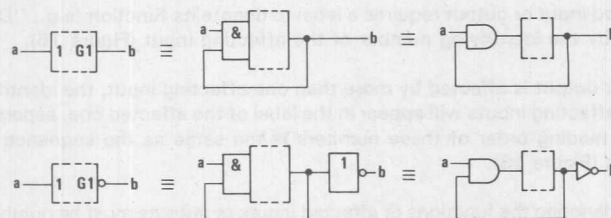


Figure 5. G Dependency Between Outputs and Inputs



Figure 6. G Dependency with a Dynamic Input

The rules for G dependency can be summarized thus:

When a  $Gm$  input or output ( $m$  is a number) stands at its internal 1 state, all inputs and outputs affected by  $Gm$  stand at their normally defined internal logic states. When the  $Gm$  input or output stands at its 0 state, all inputs and outputs affected by  $Gm$  stand at their internal 0 states.

#### 4.3 Conventions for the Application of Dependency Notation in General

The rules for applying dependency relationships in general follow the same pattern as was illustrated for G dependency.

Application of dependency notation is accomplished by:

- 1) labeling the input (or output) *affecting* other inputs or outputs with the letter symbol indicating the relationship involved (e.g., G for AND) followed by an identifying number, appropriately chosen, and
- 2) labeling each input or output *affected* by that affecting input (or output) with that same number.

If it is the complement of the internal logic state of the affecting input or output that does the affecting, then a bar is placed over the identifying numbers at the affected inputs or outputs (Figure 4).

If two affecting inputs or outputs have the same letter and same identifying number, they stand in an OR relationship to each other (Figure 7).

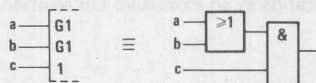


Figure 7. ORed Affecting Inputs

If the affected input or output requires a label to denote its function (e.g., "D"), this label will be *prefixed* by the identifying number of the affecting input (Figure 15).

If an input or output is affected by more than one affecting input, the identifying numbers of each of the affecting inputs will appear in the label of the affected one, separated by commas. The normal reading order of these numbers is the same as the sequence of the affecting relationships (Figure 15).

If the labels denoting the functions of affected inputs or outputs must be numbers (e.g., outputs of a coder), the identifying numbers to be associated with both affecting inputs and affected inputs or outputs will be replaced by another character selected to avoid ambiguity, e.g., Greek letters (Figure 8).

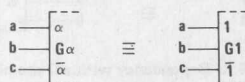


Figure 8. Substitution for Numbers

#### 4.4 V (OR) Dependency

The symbol denoting OR dependency is the letter V (Figure 9).

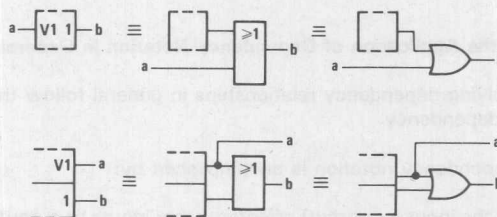
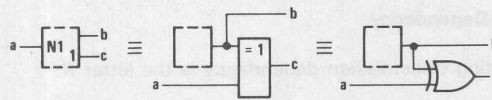


Figure 9. V (OR) Dependency

When a  $V_m$  input or output stands at its internal 1 state, all inputs and outputs affected by  $V_m$  stand at their internal 1 states. When the  $V_m$  input or output stands at its internal 0 state, all inputs and outputs affected by  $V_m$  stand at their normally defined internal logic states.

#### 4.5 N (Negate) (Exclusive-OR) Dependency

The symbol denoting negate dependency is the letter N (Figure 10). Each input or output affected by an  $N_m$  input or output stands in an Exclusive-OR relationship with the  $N_m$  input or output.



If  $a = 0$ , then  $c = b$   
 If  $a = 1$ , then  $c = \bar{b}$

Figure 10. N (Negate) (Exclusive-OR) Dependency

When an  $Nm$  input or output stands at its internal 1 state, the internal logic state of each input and each output affected by  $Nm$  is the complement of what it would otherwise be. When an  $Nm$  input or output stands at its internal 0 state, all inputs and outputs affected by  $Nm$  stand at their normally defined internal logic states.

#### 4.6 Z (Interconnection) Dependency

The symbol denoting interconnection dependency is the letter Z.

Interconnection dependency is used to indicate the existence of internal logic connections between inputs, outputs, internal inputs, and/or internal outputs.

The internal logic state of an input or output affected by a  $Zm$  input or output will be the same as the internal logic state of the  $Zm$  input or output, unless modified by additional dependency notation (Figure 11).

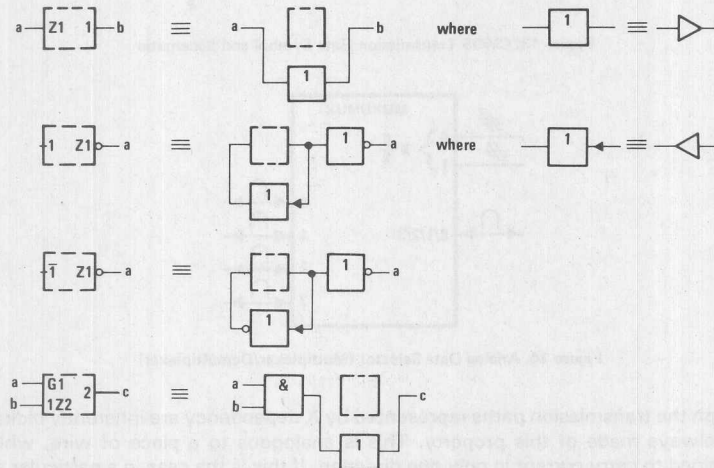


Figure 11. Z (Interconnection) Dependency

#### 4.7 X (Transmission) Dependency

The symbol denoting transmission dependency is the letter X.

Transmission dependency is used to indicate controlled bidirectional connections between affected input/output ports (Figure 12).

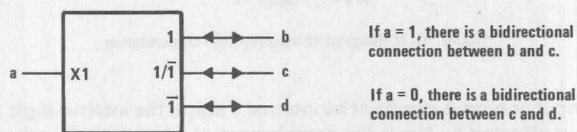


Figure 12. X (Transmission) Dependency

When an  $Xm$  input or output stands at its internal 1 state, all input-output ports affected by this  $Xm$  input or output are bidirectionally connected together and stand at the same internal logic state or analog signal level. When an  $Xm$  input or output stands at its internal 0 state, the connection associated with this set of dependency notation does not exist.

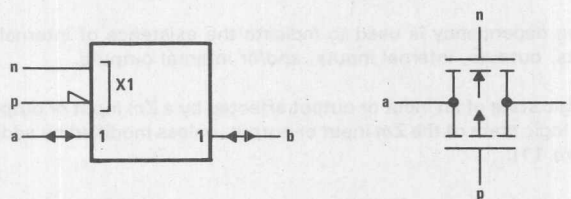


Figure 13. CMOS Transmission Gate Symbol and Schematic

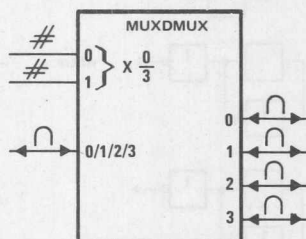


Figure 14. Analog Data Selector (Multiplexer/Demultiplexer)

Although the transmission paths represented by X dependency are inherently bidirectional, use is not always made of this property. This is analogous to a piece of wire, which may be constrained to carry current in only one direction. If this is the case in a particular application, then the directional arrows shown in Figures 12, 13, and 14 would be omitted.

#### 4.8 C (Control) Dependency

The symbol denoting control dependency is the letter C.

Control inputs are usually used to enable or disable the data (D, J, K, R, or S) inputs of storage elements. They may take on their internal 1 states (be active) either statically or dynamically. In the latter case the dynamic input symbol is used as shown in the third example of Figure 15.

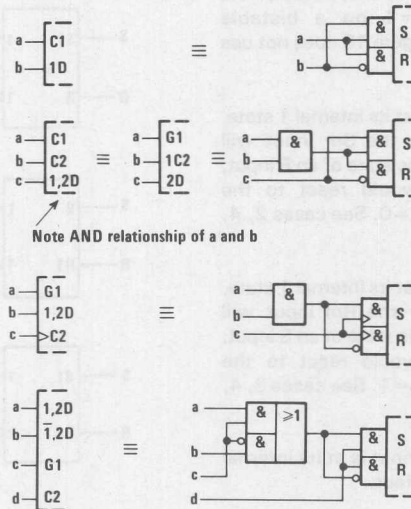


Figure 15. C (Control) Dependency

When a  $C_m$  input or output stands at its internal 1 state, the inputs affected by  $C_m$  have their normally defined effect on the function of the element, i.e., these inputs are enabled. When a  $C_m$  input or output stands at its internal 0 state, the inputs affected by  $C_m$  are disabled and have no effect on the function of the element.

#### 4.9 S (Set) and R (Reset) Dependencies

The symbol denoting set dependency is the letter S. The symbol denoting reset dependency is the letter R.

Set and reset dependencies are used if it is necessary to specify the effect of the combination  $R=S=1$  on a bistable element. Case 1 in Figure 16 does not use S or R dependency.

When an  $S_m$  input is at its internal 1 state, outputs affected by the  $S_m$  input will react, regardless of the state of an R input, as they normally would react to the combination  $S=1, R=0$ . See cases 2, 4, and 5 in Figure 16.

When an  $R_m$  input is at its internal 1 state, outputs affected by the  $R_m$  input will react, regardless of the state of an S input, as they normally would react to the combination  $S=0, R=1$ . See cases 3, 4, and 5 in Figure 16.

When an  $S_m$  or  $R_m$  input is at its internal 0 state, it has no effect.

Note that the noncomplementary output patterns in cases 4 and 5 are only pseudo stable. The simultaneous return of the inputs to  $S=R=0$  produces an unforeseeable stable and complementary output pattern.

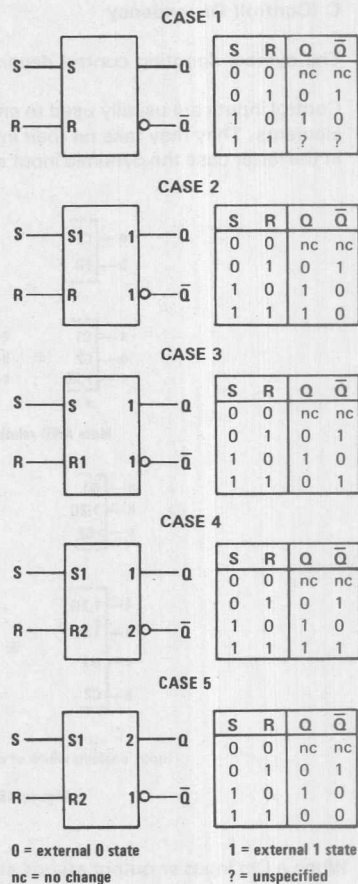


Figure 16. S (Set) and R (Reset) Dependencies

#### 4.10 EN (Enable) Dependency

The symbol denoting enable dependency is the combination of letters EN.

An  $EN_m$  input has the same effect on outputs as an EN input, see 3.3, but it affects only those outputs labeled with the identifying number  $m$ . It also affects those inputs labeled with the identifying number  $m$ . By contrast, an EN input affects all outputs and no inputs. The effect of an  $EN_m$  input on an affected input is identical to that of a  $C_m$  input (Figure 17).



When an  $ENm$  input stands at its internal 1 state, the inputs affected by  $ENm$  have their normally defined effect on the function of the element and the outputs affected by this input stand at their normally defined internal logic states, i.e., these inputs and outputs are enabled.

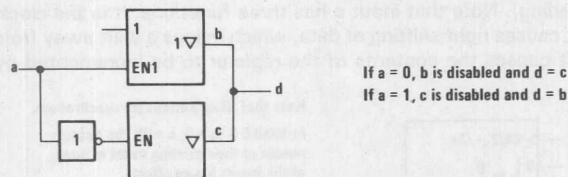


Figure 17. EN (Enable) Dependency

When an  $ENm$  input stands at its internal 0 state, the inputs affected by  $ENm$  are disabled and have no effect on the function of the element, and the outputs affected by  $ENm$  are also disabled. Open-collector outputs are turned off, three-state outputs stand at their normally defined internal logic states but externally exhibit high impedance, and all other outputs (e.g., totem-pole outputs) stand at their internal 0 states.

#### 4.11 M (MODE) Dependency

The symbol denoting mode dependency is the letter M.

Mode dependency is used to indicate that the effects of particular inputs and outputs of an element depend on the mode in which the element is operating.

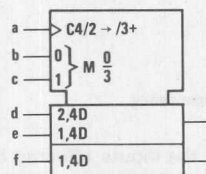
If an input or output has the same effect in different modes of operation, the identifying numbers of the relevant affecting  $Mm$  inputs will appear in the label of that affected input or output between parentheses and separated by solidi (Figure 22).

##### 4.11.1 M Dependency Affecting Inputs

M dependency affects inputs the same as C dependency. When an  $Mm$  input or  $Mm$  output stands at its internal 1 state, the inputs affected by this  $Mm$  input or  $Mm$  output have their normally defined effect on the function of the element, i.e., the inputs are enabled.

When an  $Mm$  input or  $Mm$  output stands at its internal 0 state, the inputs affected by this  $Mm$  input or  $Mm$  output have no effect on the function of the element. When an affected input has several sets of labels separated by solidi (e.g.,  $C4/2 \rightarrow /3 +$ ), any set in which the identifying number of the  $Mm$  input or  $Mm$  output appears has no effect and is to be ignored. This represents disabling of some of the functions of a multifunction input.

The circuit in Figure 18 has two inputs, **b** and **c**, that control which one of four modes (0, 1, 2, or 3) will exist at any time. Inputs **d**, **e**, and **f** are D inputs subject to dynamic control (clocking) by the **a** input. The numbers 1 and 2 are in the series chosen to indicate the modes so inputs **e** and **f** are only enabled in mode 1 (for parallel loading) and input **d** is only enabled in mode 2 (for serial loading). Note that input **a** has three functions. It is the clock for entering data. In mode 2, it causes right shifting of data, which means a shift away from the control block. In mode 3, it causes the contents of the register to be incremented by one count.



Note that all operations are synchronous.

In MODE 0 ( $b = 0, c = 0$ ), the outputs remain at their existing states as none of the inputs has an effect.

In MODE 1 ( $b = 1, c = 0$ ), parallel loading takes place thru inputs **e** and **f**.

In MODE 2 ( $b = 0, c = 1$ ), shifting down and serial loading thru input **d** take place.

In MODE 3 ( $b = c = 1$ ), counting up by increment of 1 per clock pulse takes place.

Figure 18. M (Mode) Dependency Affecting Inputs

#### 4.11.2 M Dependency Affecting Outputs

When an *Mm* input or *Mm* output stands at its internal 1 state, the affected outputs stand at their normally defined internal logic states, i.e., the outputs are enabled.

When an *Mm* input or *Mm* output stands at its internal 0 state, at each affected output any set of labels containing the identifying number of that *Mm* input or *Mm* output has no effect and is to be ignored. When an output has several different sets of labels separated by solidi (e.g., 2,4/3,5), only those sets in which the identifying number of this *Mm* input or *Mm* output appears are to be ignored.

Figure 19 shows a symbol for a device whose output can behave like either a 3-state output or an open-collector output depending on the signal applied to input **a**. Mode 1 exists when input **a** stands at its internal 1 state and, in that case, the three-state symbol applies and the open-element symbol has no effect. When  $a = 0$ , mode 1 does not exist so the three-state symbol has no effect and the open-element symbol applies.

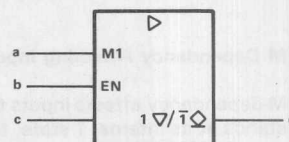


Figure 19. Type of Output Determined by Mode

In Figure 20, if input **a** stands at its internal 1 state establishing mode 1, output **b** will stand at its internal 1 state only when the content of the register equals 9. Since output **b** is located in the common-control block with no defined function outside of mode 1, the state of this output outside of mode 1 is not defined by the symbol.

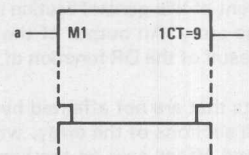


Figure 20. An Output of the Common-Control Block

In Figure 21, if input **a** stands at its internal 1 state establishing mode 1, output **b** will stand at its internal 1 state only when the content of the register equals 15. If input **a** stands at its internal 0 state, output **b** will stand at its internal 1 state only when the content of the register equals 0.

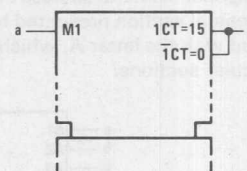


Figure 21. Determining an Output's Function

In Figure 22 inputs **a** and **b** are binary weighted to generate the numbers 0, 1, 2, or 3. This determines which one of the four modes exists.

At output **e** the label set causing negation (if  $c = 1$ ) is effective only in modes 2 and 3. In modes 0 and 1 this output stands at its normally defined state as if it had no labels. At output **f** the label set has effect when the mode is not 0 so output **e** is negated (if  $c = 1$ ) in modes 1, 2, and 3. In mode 0 the label set has no effect so the output stands at its normally defined state. In this example  $\overline{0},4$  is equivalent to  $(1/2/3)4$ . At output **g** there are two label sets. The first set, causing negation (if  $c = 1$ ), is effective only in mode 2. The second set, subjecting **g** to AND dependency on **d**, has effect only in mode 3.

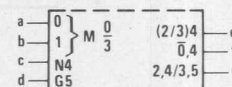


Figure 22. Dependent Relationships Affected by Mode

Note that in mode 0 none of the dependency relationships has any effect on the outputs, so **e**, **f**, and **g** will all stand at the same state.

#### 4.12 A (Address) Dependency

The symbol denoting address dependency is the letter A.

Address dependency provides a clear representation of those elements, particularly memories, that use address control inputs to select specified sections of a multidimensional arrays. Such a section of a memory array is usually called a word. The purpose of address dependency is to allow a symbolic presentation of the entire array. An input of the array shown at a particular

element of this general section is common to the corresponding elements of all selected sections of the array. An output of the array shown at a particular element of this general section is the result of the OR function of the outputs of the corresponding elements of selected sections.

Inputs that are not affected by any affecting address input have their normally defined effect on all sections of the array, whereas inputs affected by an address input have their normally defined effect only on the section selected by that address input.

An affecting address input is labeled with the letter A followed by an identifying number that corresponds with the address of the particular section of the array selected by this input. Within the general section presented by the symbol, inputs and outputs affected by an  $A_m$  input are labeled with the letter A, which stands for the identifying numbers, i.e., the addresses, of the particular sections.

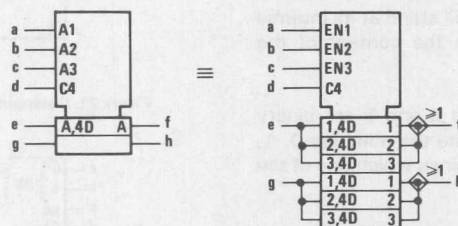


Figure 23. A (Address) Dependency

Figure 23 shows a 3-word by 2-bit memory having a separate address line for each word and uses EN dependency to explain the operation. To select word 1, input a is taken to its 1 state, which establishes mode 1. Data can now be clocked into the inputs marked "1,4D." Unless words 2 and 3 are also selected, data cannot be clocked in at the inputs marked "2,4D" and "3,4D." The outputs will be the OR functions of the selected outputs, i.e., only those enabled by the active EN functions.

The identifying numbers of affecting address inputs correspond with the addresses of the sections selected by these inputs. They need not necessarily differ from those of other affecting dependency-inputs (e.g., G, V, N, . . .), because in the general section presented by the symbol they are replaced by the letter A.

If there are several sets of affecting  $A_m$  inputs for the purpose of independent and possibly simultaneous access to sections of the array, then the letter A is modified to 1A, 2A, . . . . Because they have access to the same sections of the array, these sets of A inputs may have the same identifying numbers. The symbols for 'HC170 or SN74LS170 make use of this.

Figure 24 is another illustration of the concept.

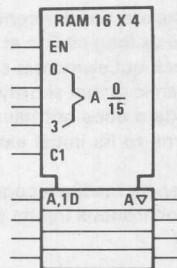


Figure 24. Array of 16 Sections of Four Transparent Latches with 3-State Outputs  
Comprising a 16-Word X 4-Bit Random-Access Memory

Table IV. Summary of Dependency Notation

TYPE OF DEPENDENCY	LETTER SYMBOL*	AFFECTING INPUT AT ITS 1-STATE	AFFECTING INPUT AT ITS 0-STATE
Address	A	Permits action (address selected)	Prevents action (address not selected)
Control	C	Permits action	Prevents action
Enable	EN	Permits action	Prevents action of inputs ◊ outputs off ▽ outputs at external high impedance, no change in internal logic state Other outputs at internal 0 state
AND	G	Permits action	Imposes 0 state
Mode	M	Permits action (mode selected)	Prevents action (mode not selected)
Negate (Ex-OR)	N	Complements state	No effect
Reset	R	Affected output reacts as it would to S = 0, R = 1	No effect
Set	S	Affected output reacts as it would to S = 1, R = 0	No effect
OR	V	Imposes 1 state	Permits action
Transmission	X	Bidirectional connection exists	Bidirectional connection does not exist
Interconnection	Z	Imposes 1 state	Imposes 0 state

\*These letter symbols appear at the AFFECTING input (or output) and are followed by a number. Each input (or output) AFFECTED by that input is labeled with that same number. When the labels EN, R, and S appear at inputs without the following numbers, the descriptions above do not apply. The action of these inputs is described under "Symbols Inside the Outline," see 3.3.

## 5.0 BISTABLE ELEMENTS

The dynamic input symbol, the postponed output symbol, and dependency notation provide the tools to differentiate four main types of bistable elements and make synchronous and asynchronous inputs easily recognizable (Figure 25). The first column shows the essential distinguishing features; the other columns show examples.

Transparent latches have a level-operated control input. The D input is active as long as the C input is at its internal 1 state. The outputs respond immediately. Edge-triggered elements accept data from D, J, K, R, or S inputs on the active transition of C. Pulse-triggered elements



require the setup of data before the start of the control pulse; the C input is considered static since the data must be maintained as long as C is at its 1 state. The output is postponed until C returns to its 0 state. The data-lock-out element is similar to the pulse-triggered version except that the C input is considered dynamic in that shortly after C goes through its active transition, the data inputs are disabled and data does not have to be held. However, the output is still postponed until the C input returns to its initial external level.

Notice that synchronous inputs can be readily recognized by their dependency labels (1D, 1J, 1K, 1S, 1R) compared to the asynchronous inputs (S, R), which are not dependent on the C inputs.

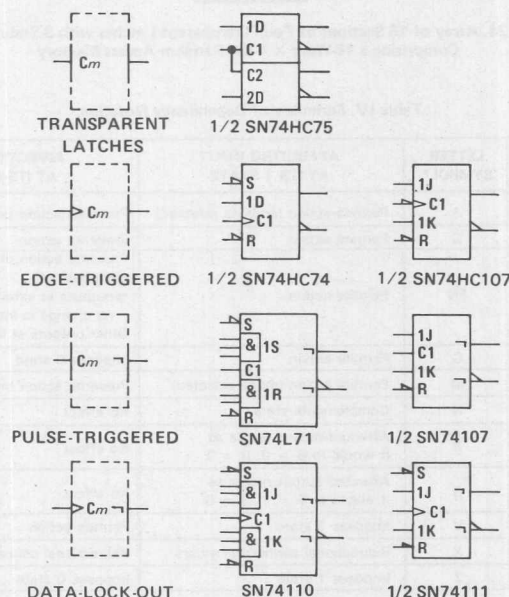


Figure 25. Four Types of Bistable Circuits

## 6.0 CODERS

The general symbol for a coder or code converter is shown in Figure 26. X and Y may be replaced by appropriate indications of the code used to represent the information at the inputs and at the outputs, respectively.



Figure 26. Coder General Symbol



Indication of code conversion is based on the following rule:

Depending on the input code, the internal logic states of the inputs determine an internal value. This value is reproduced by the internal logic states of the outputs, depending on the output code.

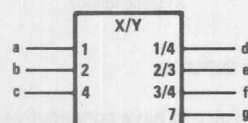
The indication of the relationships between the internal logic states of the inputs and the internal value is accomplished by:

- 1) labeling the inputs with numbers. In this case the internal value equals the sum of the weights associated with those inputs that stand at their internal 1-state, or by
- 2) replacing X by an appropriate indication of the input code and labeling the inputs with characters that refer to this code.

The relationships between the internal value and the internal logic states of the outputs are indicated by:

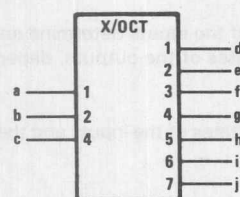
- 1) labeling each output with a list of numbers representing those internal values that lead to the internal 1-state of that output. These numbers shall be separated by solidi as in Figure 27. This labeling may also be applied when Y is replaced by a letter denoting a type of dependency (see Section 7). If a continuous range of internal values produces the internal 1 state of an output, this can be indicated by two numbers that are inclusively the beginning and the end of the range, with these two numbers separated by three dots (e.g., 4 . . . 9 = 4/5/6/7/8/9) or by
- 2) replacing Y by an appropriate indication of the output code and labeling the outputs with characters that refer to this code as in Figure 28.

Alternatively, the general symbol may be used together with an appropriate reference to a table in which the relationship between the inputs and outputs is indicated. This is a recommended way to symbolize a PROM after it has been programmed.



FUNCTION TABLE						
INPUTS			OUTPUTS			
c	b	a	g	f	e	d
0	0	0	0	0	0	0
0	0	1	0	0	0	1
0	1	0	0	0	1	0
0	1	1	0	1	1	0
1	0	0	0	1	0	1
1	0	1	0	0	0	0
1	1	0	0	0	0	0
1	1	1	1	0	0	0

Figure 27. An X/Y Code Converter



FUNCTION TABLE

INPUTS			OUTPUTS						
c	b	a	j	i	h	g	f	e	d
0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	1	0
0	1	1	0	0	0	0	1	0	0
1	0	0	0	0	0	1	0	0	0
1	0	1	0	0	1	0	0	0	0
1	1	0	0	1	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0

Figure 28. An X/Octal Code Converter

## 7.0 USE OF A CODER TO PRODUCE AFFECTING INPUTS

It often occurs that a set of affecting inputs for dependency notation is produced by decoding the signals on certain inputs to an element. In such a case use can be made of the symbol for a coder as an embedded symbol (Figure 29).

If all affecting inputs produced by a coder are of the same type and their identifying numbers shown at the outputs of the coder, Y (in the qualifying symbol X/Y) may be replaced by the letter denoting the type of dependency. The indications of the affecting inputs should then be omitted (Figure 30).

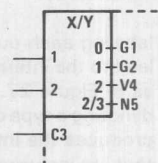


Figure 29. Producing Various Types of Dependencies

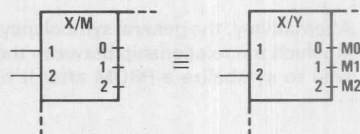


Figure 30. Producing One Type of Dependency

## 8.0 USE OF BINARY GROUPING TO PRODUCE AFFECTING INPUTS

If all affecting inputs produced by a coder are of the same type and have consecutive identifying numbers not necessarily corresponding with the numbers that would have been shown at the outputs of the coder, use can be made of the binary grouping symbol.  $k$  external lines effectively generate  $2^k$  internal inputs. The bracket is followed by the letter denoting the type of dependency followed by  $m1/m2$ . The  $m1$  is to be replaced by the smallest identifying number and the  $m2$  by the largest one, as shown in Figure 31.

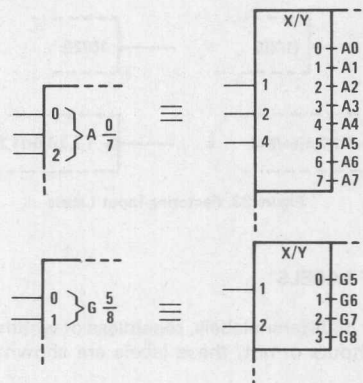


Figure 31. Use of the Binary Grouping Symbol

## 9.0 SEQUENCE OF INPUT LABELS

If an input having a single functional effect is affected by other inputs, the qualifying symbol (if there is any) for that functional effect is preceded by the labels corresponding to the affecting inputs. The left-to-right order of these preceding labels is the order in which the effects or modifications must be applied. The affected input has no functional effect on the element if the logic state of any one of the affecting inputs, considered separately, would cause the affected input to have no effect, regardless of the logic states of other affecting inputs.

If an input has several different functional effects or has several different sets of affecting inputs, depending on the mode of action, the input may be shown as often as required. However, there are cases in which this method of presentation is not advantageous. In those cases the input may be shown once with the different sets of labels separated by solidi (Figure 32). No meaning is attached to the order of these sets of labels. If one of the functional effects of an input is that of an unlabeled input to the element, a solidus will precede the first set of labels shown.

If all inputs of a combinational element are disabled (caused to have no effect on the function of the element), the internal logic states of the outputs of the element are not specified by the symbol. If all inputs of a sequential element are disabled, the content of this element is not changed and the outputs remain at their existing internal logic states.

Labels may be factored using algebraic techniques (Figure 33).

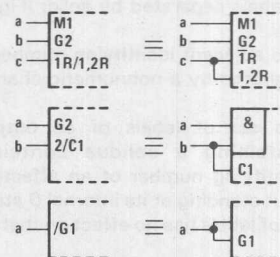


Figure 32. Input Labels

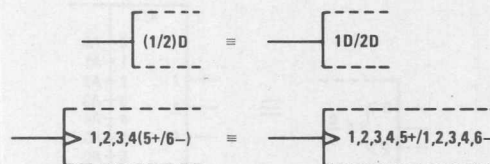


Figure 33. Factoring Input Labels

## 10.0 SEQUENCE OF OUTPUT LABELS

If an output has a number of different labels, regardless of whether they are identifying numbers of affecting inputs or outputs or not, these labels are shown in the following order:

- 1) If the postponed output symbol has to be shown, this comes first, if necessary preceded by the indications of the inputs to which it must be applied
- 2) Followed by the labels indicating modifications of the internal logic state of the output, such that the left-to-right order of these labels corresponds with the order in which their effects must be applied
- 3) Followed by the label indicating the effect of the output on inputs and other outputs of the element.

Symbols for open-circuit or three-state outputs, where applicable, are placed just inside the outside boundary of the symbol adjacent to the output line (Figure 34).

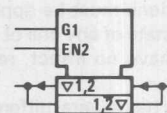


Figure 34. Placement of 3-State Symbols

If an output needs several different sets of labels that represent alternative functions (e.g., depending on the mode of action), these sets may be shown on different output lines that must be connected outside the outline. However, there are cases in which this method of presentation is not advantageous. In those cases the output may be shown once with the different sets of labels separated by solidi (Figure 35).

Two adjacent identifying numbers of affecting inputs in a set of labels that are not already separated by a nonnumeric character should be separated by a comma.

If a set of labels of an output not containing a solidus contains the identifying number of an affecting  $Mm$  input standing at its internal 0 state, this set of labels has no effect on that output.

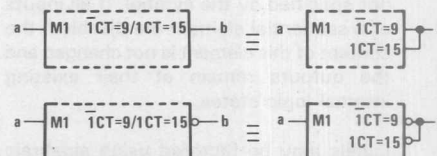


Figure 35. Output Labels

Labels may be factored using algebraic techniques (Figure 36).

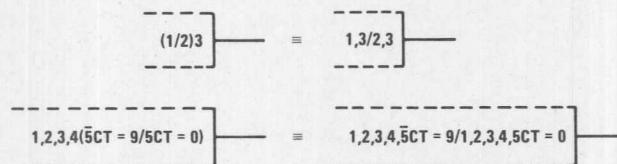


Figure 36. Factoring Output Labels

If you have questions on this Explanation of Logic Symbols, please contact:

Texas Instruments Incorporated  
F.A. Mann, MS 49  
P.O. Box 225012  
Dallas, Texas 75265  
Telephone (214) 995-2867

IEEE Standards may be purchased from:

Institute of Electrical and Electronics Engineers, Inc.  
IEEE Standards Office  
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New York, N.Y. 10017

International Electrotechnical Commission (IEC) publications may be purchased from:

American National Standards Institute, Inc.  
1430 Broadway  
New York, N.Y. 10018

# EXPLANATION OF LOGIC SYMBOLS

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## DESIGNERS' INFORMATION

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## CMOS Circuitry

The elementary CMOS building blocks are the inverter and the transmission gate. Each uses a complementary pair of one n-channel and one p-channel enhancement-type field-effect transistor. Figures 1 and 2 show these together with various logic symbols<sup>†</sup> used in this book to represent them.

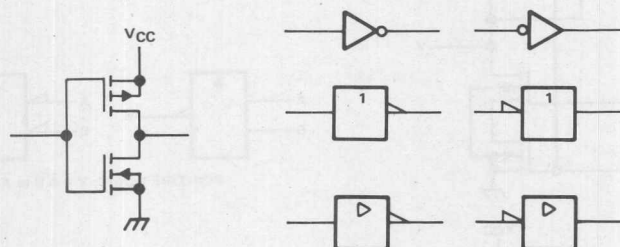


Figure 1. Inverters

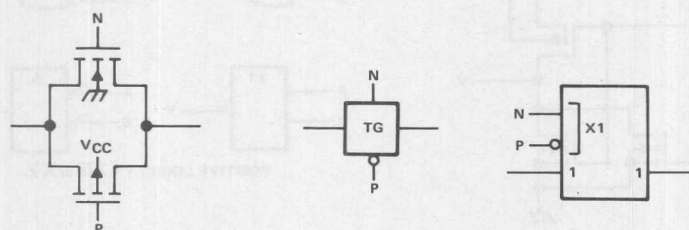
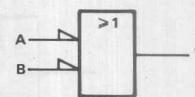
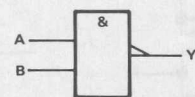
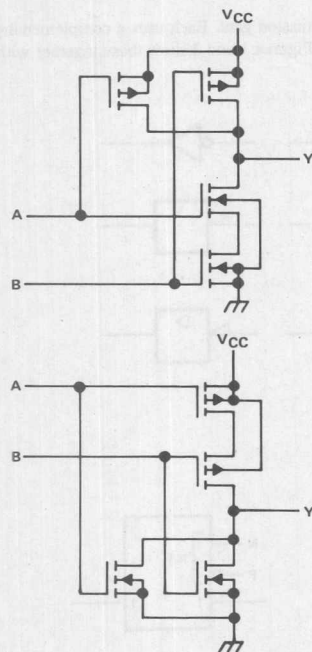


Figure 2. Transmission Gates

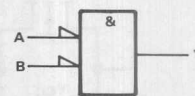
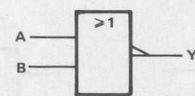
Logic gates are created by transistors added in parallel or series to the transistors making up the elementary inverter. Thus the simplest gates are inverting. See Figure 3. An odd number of additional inverters are sometimes added to the outputs of gates to make them noninverting. Basic CMOS gates usually have no more than three inputs. Arrays of gates are used when more than three signals are ANDed or ORed.

The Exclusive-OR or Exclusive-NOR gate is most easily implemented using two inverters and two transmission gates as shown in Figure 4. In complex chains of gates, the inverters may be made unnecessary by complementary signals being already available.

<sup>†</sup> The various logic symbols are equivalent. The distinctive-shape form of the inverter and gate symbols and the "TG" form of the transmission gate are usually used in the device logic diagrams. The logic inversion symbol (◐) is shown at the input or the output, whichever maintains logical consistency with the driving output or the driven input, and this technique is used to indicate the true/complement levels of the signal as it progresses through the circuit. For example, see Figure 7 in this section. The rectangular forms of the inverter and gate symbols and the polarity indicator (◐) replacing the inversion symbol are usually used in this book only in the device logic symbols. The ▷ indicates a high-current output.

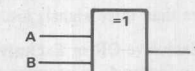
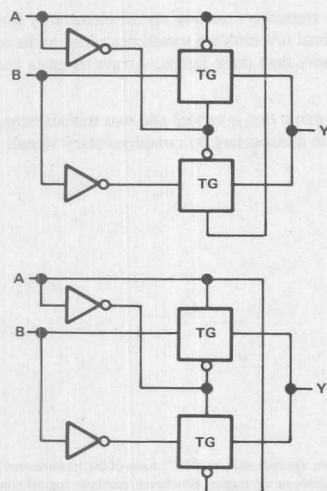


POSITIVE LOGIC:  $Y = \overline{A} \overline{B}$  or  $\overline{A+B}$

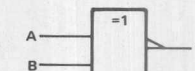
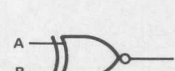


POSITIVE LOGIC:  $Y = \overline{A+B}$  or  $\overline{A} \overline{B}$

Figure 3. Gates



POSITIVE LOGIC:  $Y = \overline{A} B + A \overline{B}$  or  $A \oplus B$



POSITIVE LOGIC:  $Y = \overline{A} \overline{B} + A B$  or  $A \oplus B$

Figure 4. Exclusive-OR/NOR Gates

The three-state output buffer has logic elements in the gate connections to each of the transistors in the final inverter so that both may be turned off under the control of an enable function. Figure 5 illustrates an inverting output buffer.

The transparent latch is typically implemented as shown in Figure 6. This is the simplest form. Logic diagrams in this book show that additional inverters may be added as buffers or to optimize timing. The true and complementary outputs ( $Q$  and  $\bar{Q}$ ) may be taken off at other points. Outputs brought out to terminals are always buffered to minimize any feedback effects. The one exception to this is the 'HCU device, which has unbuffered outputs.

Putting two transparent latches in series produces the edge-triggered D-type flip-flop. The inverters can be converted to two-input gates to provide asynchronous set and reset functions. Figure 7 illustrates a negative-edge-triggered circuit. Exchanging the connections of  $C$  and  $\bar{C}$  produces a positive-edge-triggered version.

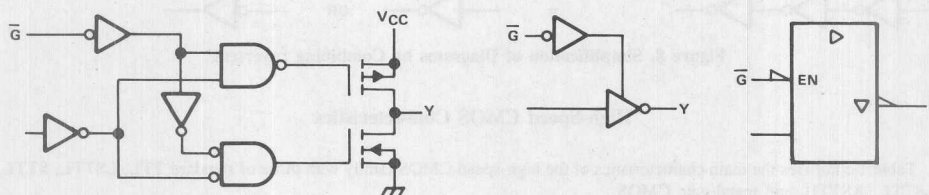


Figure 5. Inverting Three-State Output Buffer with Active-Low Enable

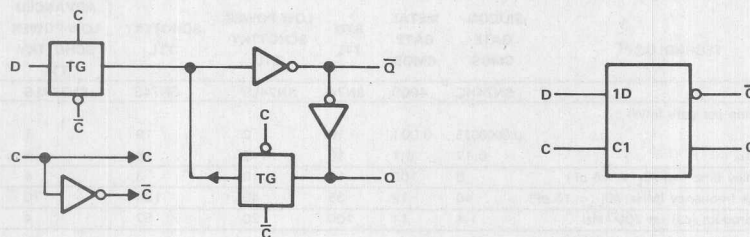


Figure 6. Transparent Latches

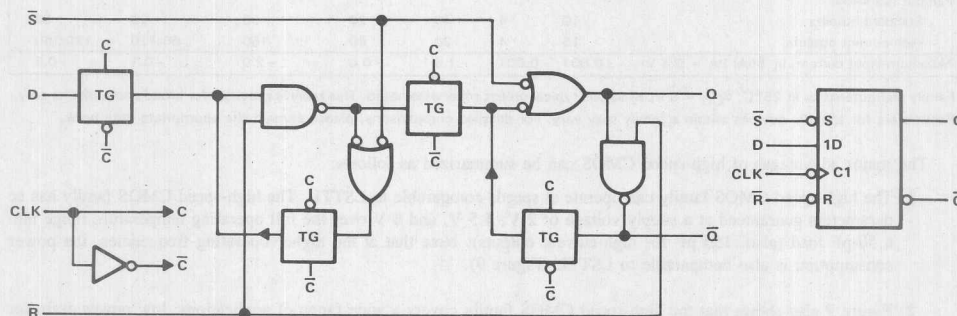


Figure 7. Negative-Edge-Triggered D-Type Flip-Flops

Detailed logic diagrams for flip-flops are given on the data sheets in this book when useful to illustrate special features such as synchronous clearing, J/K inputs, and toggle enabling.

In general the logic diagrams in this book have been simplified. They are believed to correctly indicate the logic implementation but should not be used to predict dynamic performance. Inverters existing in series may be combined or eliminated in the diagram as shown in Figure 8.

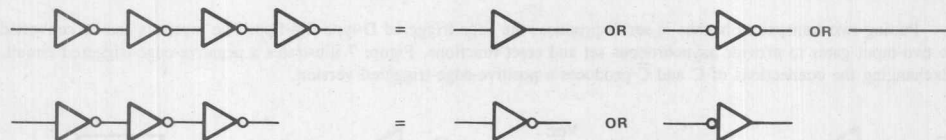


Figure 8. Simplification of Diagrams by Combining Inverters

### High-Speed CMOS Characteristics

Table 1 compares the main characteristics of the high-speed CMOS family with those of standard TTL, LSTTL, STTL, ALSTTL, ASTTL, and metal-gate CMOS.

Table 1. Performance Comparison of High-Speed CMOS with Several Other Logic Families

TECHNOLOGY†	SILICON-GATE CMOS	METAL-GATE CMOS	STD TTL	LOW-POWER SCHOTTKY TTL	SCHOTTKY TTL	ADVANCED LOW-POWER SCHOTTKY TTL	ADVANCED SCHOTTKY TTL
Device series	SN74HC	4000	SN74	SN74LS	SN74S	SN74ALS	SN74AS
Power dissipation per gate (mW)							
Static	0.0000025	0.001	10	2	19	1	8.5
At 100 kHz	0.17	0.1	10	2	19	1	8.5
Propagation delay time (ns) ( $C_L = 15$ pF)	8	105	10	10	3	4	1.5
Maximum clock frequency (MHz) ( $C_L = 15$ pF)	40	12	35	40	125	70	200
Speed/Power product (pJ) (at 100 kHz)	1.4	11	100	20	57	4	13
Minimum output drive (mA) ( $V_O = 0.4$ V)							
Standard outputs	4	1.6	16	8	20	8	20
High-current outputs	6	1.6	48	24	64	24/48	48/64
Fan-out (LS loads)							
Standard outputs	10	4	40	20	50	20	50
High-current outputs	15	4	120	60	160	60/120	120/160
Maximum input current, $I_{IL}$ (mA) ( $V_I = 0.4$ V)	$\pm 0.001$	$-0.001$	$-1.6$	$-0.4$	$-2.0$	$-0.1$	$-0.5$

† Family characteristics at 25°C,  $V_{CC} = 5$  V; all values typical unless otherwise noted. This table is provided for broad comparisons only. Parameters for specific devices within a family may vary. For detailed comparisons, please consult the appropriate data book.

The major advantages of high-speed CMOS can be summarized as follows:

1. The high-speed CMOS family can operate at speeds comparable to LSTTL. The high-speed CMOS family has ac parameters guaranteed at a supply voltage of 2 V, 4.5 V, and 6 V over the full operating temperature range into a 50-pF load (also, 150 pF for high-current outputs). Note that at the higher operating frequencies, the power consumption is also comparable to LSTTL (Figure 9).
2. Figure 9 also shows that the high-speed CMOS family covers a wide range of applications: low power drain for low-speed systems, and a slightly higher drain for higher speed systems.



3. Minimum system power — only the gates that are switching contribute to system power consumption. This reduces the size of the power supply required, hence provides lower system cost and improved reliability through lower heat dissipation.

As mentioned previously, the power consumption for an individual gate at the maximum speed is comparable to LSTTL. However in typical systems, only a fraction of the gates are switching at the clock frequency; therefore, significant power savings can be realized. On a system level where the individual gate switching frequencies are distributed between zero and the system clock frequency (Figure 10), the power saved with high-speed CMOS can be quite significant, as illustrated in Figure 11. The total system power is the area under each curve. The graph in Figure 11 is obtained by multiplying the individual gate characteristics (Figure 9) by the frequency distribution in Figure 10.

4. High-speed CMOS is ideal for battery-operated systems, or systems requiring battery back-up, because there is virtually no static power dissipation (Figure 9).

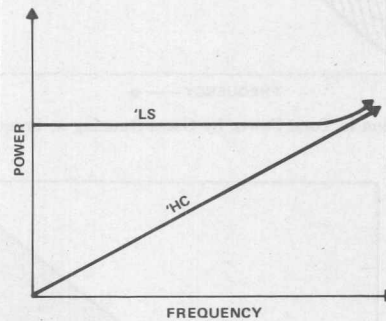


Figure 9. Power Consumed Versus Frequency for High-Speed CMOS Compared to LSTTL

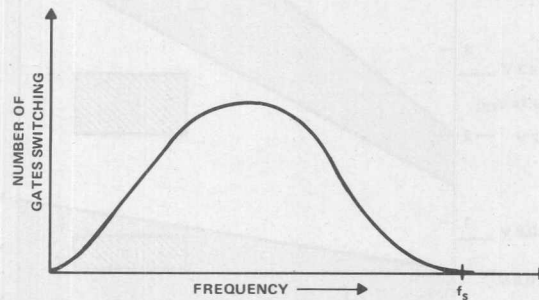


Figure 10. Typical Distribution of Switching Frequencies for Gates within a System with Maximum Clock Frequency,  $f_s$

5. Improved noise immunity over bipolar devices is due to the rail-to-rail ( $V_{CC}$  to ground) output voltage swings. Figure 12 illustrates the noise immunity provided by the high-speed CMOS family as it compares to the LSTTL family. This noise immunity makes it ideal for high-noise environments. Minimum and maximum output voltages are guaranteed at 4 mA (6 mA for high-current devices). If the output currents exceed these limits, the noise immunity will be impaired. 'HCT devices have similar input noise margins to LSTTL because their inputs are TTL-voltage compatible. The outputs of 'HCT are the same as standard 'HC outputs.

6. High-speed CMOS devices can drive up to 10 LSTTL loads (15 LSTTL loads for high-current outputs) while maintaining good noise immunity. Although  $V_{OHmin}$  and  $V_{OLmax}$  are guaranteed for output currents up to 4 mA (6 mA for high-current outputs), currents up to  $\pm 25$  mA ( $\pm 35$  mA for high-current outputs) can be obtained to drive LEDs or relays (see Driving LEDs and Relays in this section.)

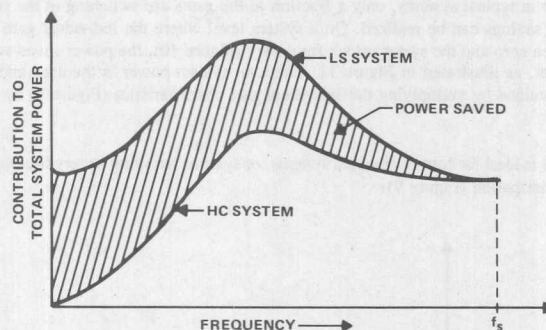


Figure 11. Contribution to Total Power by Gates Running at Frequencies from 0 to  $f_s$

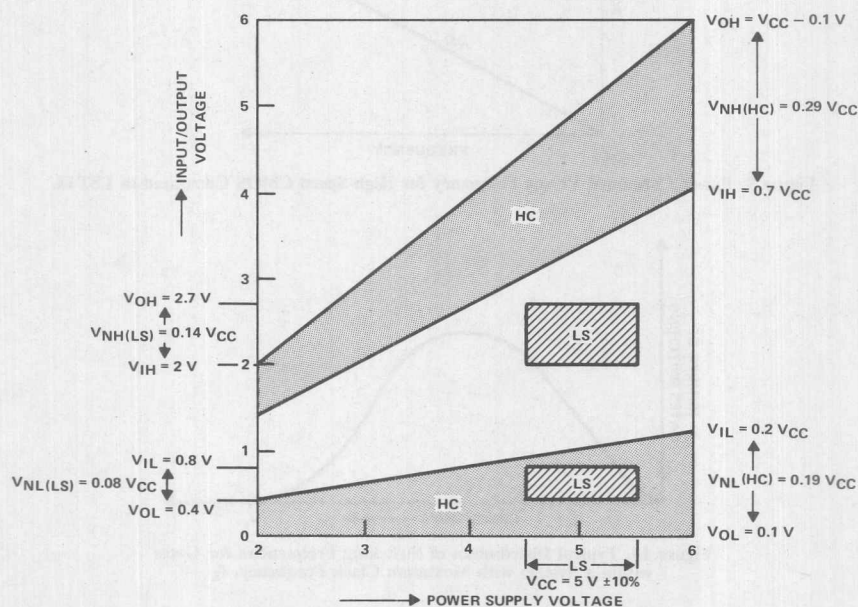


Figure 12. High-Speed CMOS and LS Noise Margins

SN54HC/HCT	-55°C to 125°C	(military)
SN74HC/HCT	-40°C to 85°C	(industrial)

All specified ac and dc characteristics are guaranteed over this range with the exception of Power Dissipation Capacitance ( $C_{pd}$ ), which is specified as a typical value at 25°C.

## Protection Circuitry

Electrostatic discharge (ESD) and latch-up are two traditional causes of CMOS device failure. In order to protect HCMOS devices from ESD and latch-up, additional circuitry has been implemented on the inputs and outputs.

### ESD PROTECTION

ESD occurs when a buildup of static charges on one surface arcs through a dielectric to another surface that has the opposite charge. The end effect is the ESD causes a short between the two surfaces. These damaged devices (walking-wounded) may still pass normal data sheet tests, but will eventually fail. The unique input protection circuitry designed by Texas Instruments provides immunity to typically 4500 V on the inputs and 3000 V on the outputs, which exceeds MIL-STD-883B, Method 3015, requirements for ESD protection (2000 V, 1.5 k $\Omega$ , 100 pF).

Figure 13 shows the circuitry implemented to provide protection for the input gates against ESD. The diode is forward biased for input voltages greater than  $V_{CC} + 0.5$  V. The two transistors and resistor (actually one transistor diffused across a resistor) act as a resistor-diode network against negative-going transients. As illustrated in Figure 14, the ESD protection for the output consists of an additional diffused diode (D3) from the output to  $V_{CC}$ . The other diodes (D1 and D2) are parasitics. For further information on handling CMOS devices, see Guidelines for Handling ESDS Devices and Assemblies in this section.

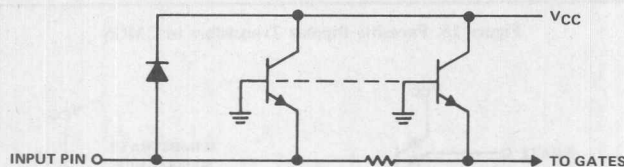


Figure 13. ESD Input Protection Circuitry

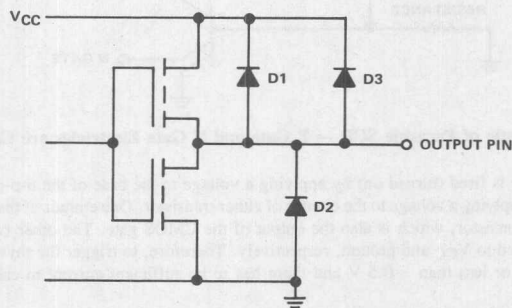
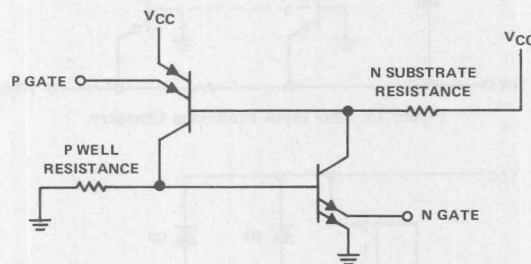


Figure 14. ESD Output Protection Circuitry.  
D1 and D2 are Parasitic Diodes

## DESIGNERS' INFORMATION

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**Figure 16. Schematic of Parasitic SCR — P Gate and N Gate Electrodes are Connected Together**

Latch-up cannot be completely eliminated! The alternative is to impede the thyristor from triggering. Texas Instruments has improved the circuit design by adding four additional diffusions or guard rings alternately connected to  $V_{CC}$  and ground as shown in Figure 17. The guard rings provide isolation between the device pins and any p-n junction that is not isolated by a transistor gate. All internal p-n junctions are separated by two guard rings. Tests have shown effective latch-up protection ranges from 450 mA to greater than 1 A at 25°C, and typically greater than 250 mA at 125°C.

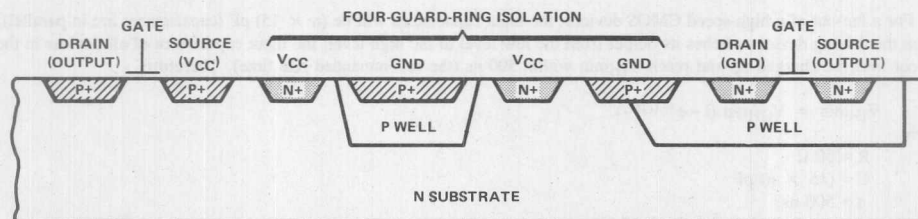


Figure 17. Unique Latch-Up Suppression Utilizes Guard Rings to Virtually Eliminate Latch-Up

### Fan-Out and Capacitance Loading Effects

High-Speed CMOS is capable of driving up to 10 LSTTL loads from a single standard output, or 15 loads from a high-current output. From the dc values in Table I on page 2-4, the fan-out of high-speed CMOS devices is unlimited for all practical purposes. However, from an ac point of view, there is a definite limit to the fan-out. The limiting constraint is the input rise time.

With a worst-case model, about 15 pF of capacitance is associated with the input of a high-speed CMOS device (10 pF from the device itself plus 5 pF of stray capacitance; typically the input capacitance is 3 pF for all devices except the transceivers, which are 6 pF). The input resistance,  $r_i$ , can be approximated with the following equation using the information in Table I on page 2-4.

$$r_i = V_I / I_I$$

where

$$V_I = V_{CC} = 6 \text{ V}$$

$$I_I = 0.1 \text{ nA}$$

The output resistance can also be calculated from the values in Table I, page 2-4 and the following equation:

$$r_o = (V_{CC} - V_{OH}) / I_{OH}$$

where

$$V_{CC} = 4.5 \text{ V}$$

$$V_{OH} = 4.3 \text{ V (typical)}$$

$$I_{OH} = 4 \text{ mA}$$

The calculated input resistance is about 60 M $\Omega$  and the maximum output resistance is approximately 50  $\Omega$ . Figure 18 shows the schematic of the output and the input models using the values previously determined.

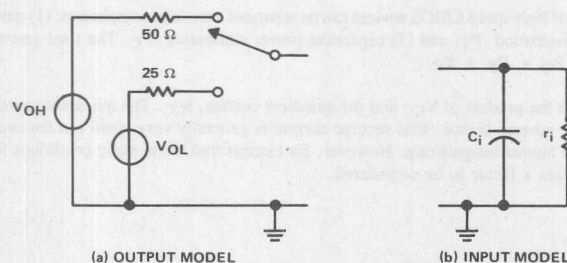


Figure 18. Worst-Case Output and Input Circuits of High-Speed CMOS

$$V_{IHmin} = V_{OHtyp} (1 - e^{-t/RC})$$

where

$$R = 50 \, \Omega$$

$$C = (15 \times n) \, \text{pF}$$

$$t = 500 \, \text{ns}$$

$$n = \text{number of devices in the fan-out}$$

Taking the natural log of both sides:

$$-t/RC = \ln(1 - V_{IHmin}/V_{OHtyp})$$

Substituting in the appropriate values and solving for  $n$  indicates that the maximum fan-out of high-speed CMOS devices is approximately 505. Alternately, solving for  $t$  in terms of  $n$  shows that each high-speed CMOS device added to the fan-out will increase the propagation delay from input of the driving device to the input of the driven devices by about 0.989 ns. This corresponds to approximately 0.066 ns/pF of added delay. Table 2 contains typical values of fan-out and capacitive loading effects at different values of  $V_{CC}$ .

**Table 2. Typical Fan-Out of High-Speed CMOS Devices and Propagation Delay per pF at Various Values of  $V_{CC}$**

$V_{CC}$	$V_{OHmin}$	$V_{IHmin}$	$n$	$t_{pd}/\text{pF}$
2 V	1.9 V	1.4 V	936	0.0667 ns
4.5 V	4.4 V	3.15 V	993	0.0629 ns
6 V	5.9 V	4.2 V	1004	0.0623 ns

NOTE:

$$n = \frac{-t/RC}{\ln \left[ 1 - \frac{V_{IHmin}}{V_{OHmin}} \right]}$$

where

$$R = 50 \, \Omega$$

$$C = 8 \, \text{pF}$$

$$n = \text{number of devices in the fan-out}$$

$$t_{pd}/\text{pF} = \frac{500 \, \text{ns}}{n \times 8 \, \text{pF}}$$

### Power Dissipation

The power dissipation of high-speed CMOS devices can be separated into three components: (1) quiescent power dissipation,  $P_Q$ ; (2) transient power dissipation,  $P_T$ ; and (3) capacitive power dissipation,  $P_C$ . The total power dissipation is the sum of the three components,  $P_Q + P_T + P_C$ .

The quiescent power is the product of  $V_{CC}$  and the quiescent current,  $I_{CC}$ . The quiescent current is the reverse current through the diodes that are reverse biased. This reverse current is generally very small (on the order of a few nA), which makes the quiescent power almost insignificant. However, for circuits that are in static conditions for long periods of time, the quiescent power becomes a factor to be considered.



The transient power is due to the current that flows only during the time the transistors are switching from one logic level to the other. During this time both transistors are partially on (one turning off, the other turning on), which produces a low-impedance path between  $V_{CC}$  and ground and results in a current spike. The rise (and fall) time of the input signal has a direct effect on the duration of the current spike. This is because the faster the input signal goes through the transition region, the less time both transistors are partially on. The transient power is dependent on the characteristics of the transistors, the switching frequency, and the rise time of the input signal. This component can be calculated using the following equation:

$$P_T = C_{pd} \times V_{CC}^2 \times f_i$$

where

$C_{pd}$  = power dissipation capacitance (specified on each data sheet)

$V_{CC}$  = supply voltage

$f_i$  = input signal frequency

Additional capacitive power dissipation is caused by the charging and discharging of the external load capacitance and is dependent on the switching frequency. To calculate this power, the following equation may be used:

$$P_C = C_L \times V_{CC}^2 \times f_o$$

where

$C_L$  = external (load) capacitance

$V_{CC}$  = supply voltage

$f_o$  = output signal frequency

### 'HCT POWER DISSIPATION

'HCT devices are primarily used to interface TTL output signals to high-speed CMOS inputs. To make the inputs of the 'HCT devices TTL-voltage compatible, the input transistor geometries were changed. This increased the power consumption compared to the equivalent 'HC device, however 'HCT still provides a considerable savings in power over TTL. The increase in power consumption is due to the fact that the TTL input levels cause both transistors in the transistor pair to be partially turned on. Included in the dc tables for 'HCT devices (Tables V through VIII in Section 2) is a parameter  $\Delta I_{CC}$ , which enables the designer to compute how much additional current the 'HCT device draws per input when at a TTL voltage level.

### Power Supply Decoupling

When an SN54HC/74HC gate switches, there is a brief period (on the order of a nanosecond) during which both transistors in the gate output buffer (Figure 19) are partially on. In this interval, the device draws a substantial supply current, producing a current spike on the  $V_{CC}$  and ground leads to the gate. This spike may exhibit  $di/dt$  as high as 5000 A/s. These spikes will react with the distributed inductance of the supply wiring to produce significant voltage transients on  $V_{CC}$  and ground unless adequate supply decoupling is provided. These transients, if allowed, will couple directly into the gate outputs, which in normal usage switch from rail-to-rail.

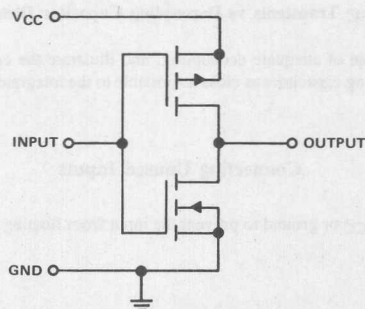


Figure 19. Gate Output Buffer

## DECOUPLING PROCEDURE

Figure 20 illustrates a circuit for testing the effectiveness of decoupling. In this test circuit, the  $V_{CC}$  and ground connections consist of two parallel runs of one-eighth inch copper on a G-10 epoxy-glass circuit board. As a  $0.01\text{-}\mu\text{F}$  decoupling capacitor between  $V_{CC}$  and ground is physically moved away from a driven gate in 1.5-inch increments,  $V_{CC}$  transients increase as shown in Figure 21.

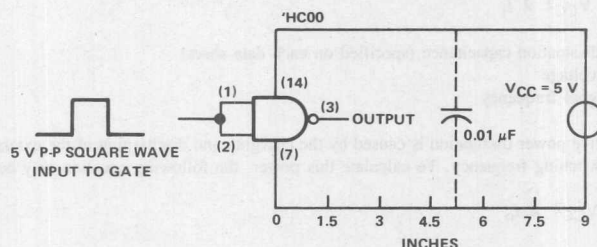


Figure 20. Test Circuit for Decoupling Effects

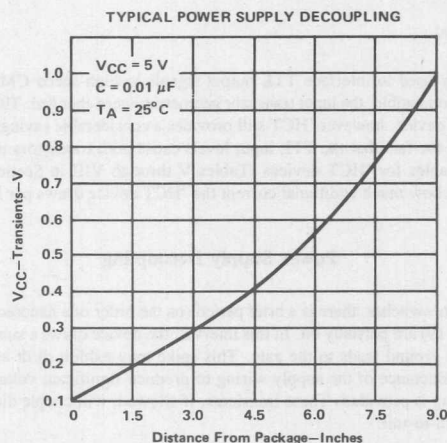


Figure 21.  $V_{CC}$  Transients vs Decoupling Capacitor Distance from DIP

The results indicate the importance of adequate decoupling, and illustrate the correct procedure for obtaining it. This procedure consists of locating decoupling capacitors as close as possible to the integrated circuit package, in order to maximize noise margins.

## Connecting Unused Inputs

Unused inputs should be tied to  $V_{CC}$  or ground to prevent the input from floating. If left to float, the power consumption of the device will increase.

## Matching

Another factor to consider when designing with high-speed CMOS is the  $V_{OHmin}$ -to- $V_I$  matching. This is important when the  $V_{OHmin}$  of the driving device exceeds the  $V_{CC} + 0.5$  V of the driven device. If this occurs, the ESD protection diode on the inputs will be forward biased. At this point, the driving device will attempt to "power-up" the driven device's power supply. No damage will occur to the driven device, provided the current flowing through the diode does not exceed 20 mA.

## Powering Up/Down Sequence for High-Speed CMOS

To avoid any possible damage and reliability problems to the high-speed CMOS devices when applying power, the following steps should be followed:

1. Connect ground
2. Connect  $V_{CC}$
3. Connect the input signal

When powering down a high-speed CMOS device, follow the above steps in reverse order.

## High-Speed CMOS Interfacing

### INTRODUCTION

The High-Speed CMOS logic family from Texas Instruments contains a broad spectrum of SSI/MSI functions. Within this family are TTL functions, HCT devices, HC4000 series, and an HCU device.<sup>1</sup> Entire CMOS systems may be implemented using this logic family. There is also a broad range of CMOS-system to non-CMOS-system interfaces that need to be considered. The design engineer will inevitably encounter these interfaces. To develop the necessary interfaces, a thorough understanding of data sheet parameters of both systems and an organized approach is recommended. This report uses basic examples to present one possible approach to the SN54/74HC interface solution.

There are two types of interfacing that must be considered: (1) interfacing CMOS system signals to non-CMOS systems and (2) interfacing non-CMOS system signals to CMOS systems. The first type requires an understanding of the CMOS output parameters and the non-CMOS input parameters and vice versa for the second type. In both cases, a model of the inputs and outputs of both systems may be useful.

### GENERAL INTERFACING SOLUTION

An interfacing problem arises when the output logic levels and/or the current requirements of the driving system (or device) are different from the input logic levels and/or the current requirements of the driven system (or device). When determining the compatibility of the systems (or devices), the most important system/device parameters are  $V_{IH}$ ,  $V_{IL}$ ,  $V_{OH}$ ,  $V_{OL}$ ,  $I_{IH}$ ,  $I_{IL}$ ,  $I_{OH}$ , and  $V_{OL}$ .

Figure 22 is the voltage transfer characteristic of a typical unloaded inverter showing the various input and output voltage parameters. Loading the output of the inverter will tend to lower  $V_{OH}$  and raise  $V_{OL}$ . The tables of electrical characteristics specify minimum  $V_{OH}$  and maximum  $V_{OL}$  for various loads.

### Noise Margin

There are two noise margins to be considered: the low-voltage noise margin and the high-voltage noise margin. The voltage difference between  $V_{ILmax}$  of the driven system/device and  $V_{OLmax}$  of the driving system/device is the low-voltage noise margin. The voltage difference between  $V_{OHmin}$  of the driving system/device and  $V_{IHmin}$  of the driven system/device is the high-voltage noise margin (Figure 23).

<sup>1</sup> HCT devices are explained later. The HC4000 series devices are pin-for-pin functionally compatible, but not electrically compatible, with the older metal-gate CMOS devices. The HCU device is unbuffered.

It is desirable to have the noise margin as large as possible and the uncertain region (the difference between  $V_{IHmin}$  and  $V_{ILmax}$ ) as small as possible. When an input voltage falls into the uncertain region, we do not know how the output in conjunction with other inputs driven by that output will respond. The problem with small noise margins is that any noise on the output of the driving system or device will cause the signal to fall into the uncertain region and possibly cause a bit error in the system. There are various sources of noise in digital systems. Three possible internal sources are inductive and resistive drops, capacitive coupling from another logic node, and mutual inductance with another logic node. Radio signals are possible external sources of noise.

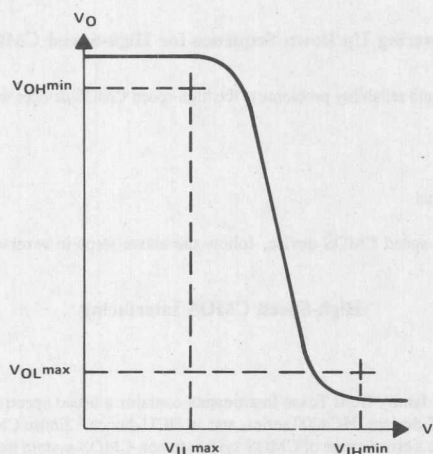


Figure 22. Voltage Transfer Characteristic of a Typical Inverter

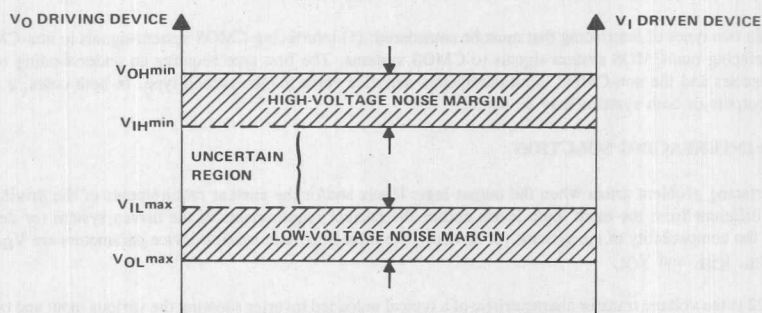


Figure 23. Noise Margins

As an aid for interfacing between the various TTL families, the eight parameters previously defined are shown in Table 3. The values are for  $V_{CC} = 5\text{ V}$  and  $T_A = 25^\circ\text{C}$  (worst-case device parameters — the device will perform at least this well). All currents are designated positive when flowing into the device.

Table 3. Worst-Case Values of Primary Interfacing Parameters

PARAMETER	74HCMOS	74TTL	74LSTTL	74ASTTL	74ALSTTL
$V_{IHmin}$	3.5 V	2 V	2 V	2 V	2 V
$V_{ILmax}$	1 V	0.8 V	0.8 V	0.8 V	0.8 V
$V_{OHmin}$	4.9 V	2.4 V	2.7 V	2.7 V	2.7 V
$V_{OLmax}$	0.1 V	0.4 V	0.4 V	0.4 V	0.4 V
$I_{IHmax}$	1 $\mu$ A	40 $\mu$ A	20 $\mu$ A	200 $\mu$ A	20 $\mu$ A
$I_{ILmax}$	-1 $\mu$ A	-1.6 mA	-400 $\mu$ A	-2 mA	-100 $\mu$ A
$I_{OHmax}$	-4 mA	-400 $\mu$ A	-400 $\mu$ A	-2 mA	-400 $\mu$ A
$I_{OLmax}$	4 mA	16 mA	8 mA	20 mA	4 mA

### Driving Gate Output Model

Figure 24 shows the model of a driving gate derived from the data sheet specifications.  $V_{OH(nl)}$  (nl = no load) is the high-level output voltage expected when the output gate is unloaded.  $V_{OL(nl)}$  is the low-level output voltage expected when the output gate is unloaded. The values for these two voltages are usually not given on the data sheets. As a rule of thumb for MOS devices, the output switches between the power rails  $V_{OH(nl)} = V_{CC}$  and  $V_{OL(nl)} = GND$ ; for bipolar devices (e.g., the TTL Family)  $V_{OL(nl)}$  is about  $V_{CC(sat)}$  or about 0.3 V. Within the TTL family  $V_{OH(nl)}$  varies. Standard TTL has a  $V_{OH(nl)}$  within two base-emitter drops of  $V_{CC}$  ( $V_{OH(nl)} = V_{CC} - 1.2$  V); LSTTL has a  $V_{OH(nl)}$  within one base-emitter drop of  $V_{CC}$  ( $V_{OH(nl)} = V_{CC} - 0.6$  V). The data sheets specify  $V_{OHmax}$  and  $V_{OLmax}$  at a nonzero  $I_{OH}$  and  $I_{OL}$ , respectively. Therefore to calculate the approximate series resistances, the following two equations may be used:

$$R_{OH} = \frac{V_{OH(nl)} - V_{OHmin}}{I_{OH}}$$

$$R_{OL} = \frac{V_{OL(nl)} - V_{OLmax}}{I_{OL}}$$

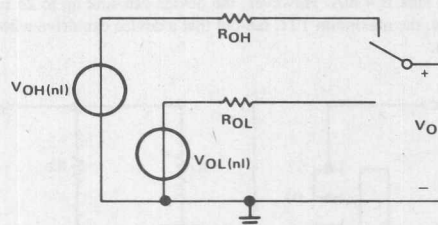


Figure 24. Output Model of a Driving Gate

### Input Gate Circuit

A simplified schematic of a high-speed CMOS input gate is shown in Figure 25. The diode D1 and the transistors Q1 and Q2 provide static discharge and input transient clamping for the device. Any inputs higher than  $V_{CC} + 0.5$  V or lower than -0.5 V will clamp the input. The capacitors C1 and C2 represent the parasitic capacitances present at the gate input. The data sheet specifies that the input capacitance ( $C1 + C2$ ) will not exceed 10 pF (typical is about 5 pF). The input capacitance is split between  $V_{CC}$  and ground of the device and provides a feedback path between  $V_{CC}$  and the input. If the input is driven by a high-impedance source, then any transient noise on  $V_{CC}$  may be coupled back into the input.

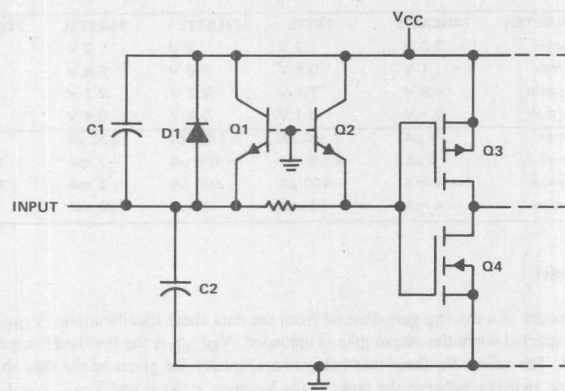


Figure 25. SN54/74HC Input Gate

#### CMOS-to-STANDARD-TTL INTERFACE

CMOS devices can drive TTL loads with no additional interfacing required. The output voltages of CMOS devices are compatible with the input voltage requirements of TTL devices. The input current requirements of the TTL devices does place a strict limitation on the number of TTL devices that CMOS devices can drive from a single output (the fan-out):

Figure 26 is a schematic of a CMOS output gate driving a TTL input gate. When the CMOS gate drives the emitter of Q3 low, a current will flow into the CMOS gate from R1 and the emitter of the TTL gate. The maximum guaranteed current that the CMOS device can sink is 4 mA. However, the device can sink up to 25 mA, but the output voltage is not guaranteed above 4 mA. Therefore, the maximum TTL fan-out that a device can drive without exceeding the specified limit is two ( $I_{IL}$  for TTL is  $-1.6$  mA).

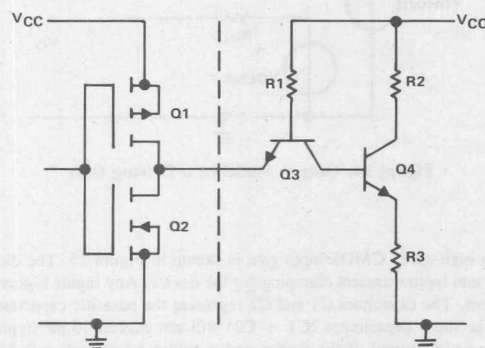


Figure 26. SN54/74HC to TTL Interface

#### STANDARD TTL-to-CMOS INTERFACE

The interface for TTL driving CMOS is not as simple as the CMOS-to-Standard-TTL interface. Taking the voltage levels from Table 3, it can be seen they are not compatible as far as  $V_{OHmin}$  of the TTL device and  $V_{IHmin}$  of the CMOS device. Figure 27 shows the schematic of TTL to CMOS interface. The pull-up resistor  $R_p$  eliminates the voltage incompatibility.



The lower limit of the pull-up resistor is determined by the current-sinking capability of the driving device (TTL for this interface). When the TTL device output goes low, Q3 (Figure 27) will be required to sink a current of  $(V_{CC} - V_{OLmax})/R_p$  in addition to the sum of the output currents of the driven devices  $I_{IL}$  worst case. All of this is shown in the following equation:

$$R_{pmin} = \frac{V_{CC} - V_{OLmax} (TTL)}{I_{OL}(TTL) + n I_{IL}(load)}$$

where  $n$  is the number of loads being driven, and  $V_{CC}$  is the voltage applied to the pull-up resistor.

Example: An SN74LS00 is driving three SN74HC00 devices.  $V_{CCmin} = 4.75$  V,  $V_{OLmax} = 0.4$  V,  $I_{OL} = 8$  mA,  $I_{IL} = 1$   $\mu$ A,  $n = 3$ , therefore  $R_{pmin} = 543$   $\Omega$ .

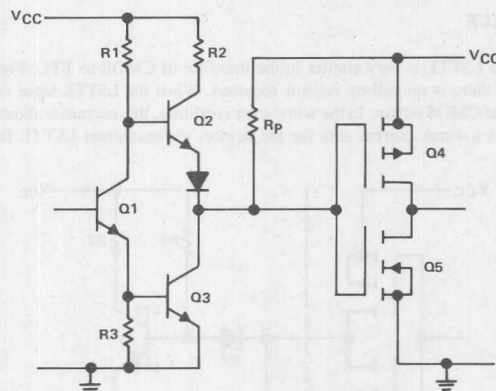


Figure 27. TTL to SN54/74HC Interface with a Pull-Up Resistor

The upper limit of the pull-up resistor is determined by two factors: (1) the total input capacitance of the loads and (2) the total high-level input currents of the loads. When the TTL output goes high, Q2 is turned off due to the pull-up resistor. Therefore, all the current that flows into the devices that are being driven flows through the pull-up resistor  $R_p$ . The input voltage of the CMOS devices will therefore rise exponentially with a time constant of  $R_p C_i$  ( $C_i = 10$  pF max). The time constant cannot exceed the 500-ns rise time requirement of the CMOS device. Along with this limitation, the total input currents must not cause the voltage drop across the pull-up resistor to exceed  $V_{IHmin}$  for the CMOS devices. Bringing all this into play, the following equation may be used to determine  $R_{pmax}$ .

$$R_{pmax} = \frac{V_{CC} - V_{IHmin} (load)}{[n I_{IH}(load) - I_{OH}(driver)]}$$

where  $n$  is the number of loads being driven, and  $V_{CC}$  is the voltage applied to the pull-up resistor.

Example: An SN74LS00 is driving three SN74HC00 devices.  $V_{CC} = 5.25$  V,  $V_{IHmin} = 3.675$  V,  $I_{IH} = 1$   $\mu$ A,  $I_{OH} = 0$ ,  $n = 3$ , therefore  $R_{pmax} = 525$  k $\Omega$ .

However, if the rise time is calculated using this value of  $R_{pmax}$ , the recommended 500 ns will be exceeded.

From the relationship:

$$V_{IHmin} = V_{CCmax} (1 - e^{-t/R_p C_i})$$

with

$$V_{IHmin} = 3.675 \text{ V and } V_{CCmax} = 5.25 \text{ V}$$

then

$$R_p = \frac{t}{1.2 C_i} = 13.8 \text{ k}\Omega \text{ for } t = 500 \text{ ns and } C_i = 30 \text{ pF}$$

Generally, this rise-time constraint is the limiting factor on the upper limit of the pull-up resistor.

#### CMOS-to-LSTTL INTERFACE

The interface of CMOS to LSTTL is very similar to the interface of CMOS to TTL. Figure 28 shows a schematic of the interface. As can be seen, there is no pull-up resistor required. When the LSTTL input is pulled low, the current will flow through R1 and D2 into the CMOS output. In the worst-case condition, this current is about 0.4 mA. Because the CMOS output parameter  $I_{OL}$  specifies a 4-mA current sink for the device, the maximum LSTTL fan-out is ten.

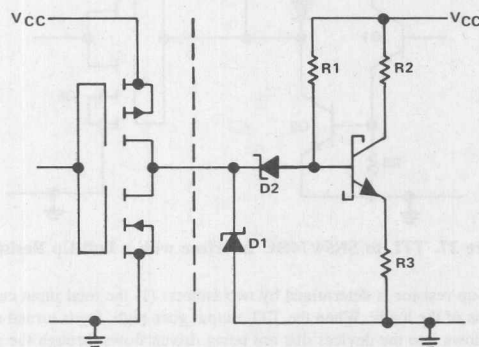


Figure 28. SN54/74HC to LSTTL Interface

#### LSTTL-to-CMOS INTERFACE

For an LSTTL device to drive a CMOS device, a pull-up resistor must be used because the  $V_{OHmin}$  of the LSTTL is less than the specified  $V_{IHmin}$  of the CMOS device. Figure 29 shows the schematic of the LSTTL/CMOS interface. The upper and lower limits of the pull-up resistor are determined in the same method as the TTL/CMOS interface. Remember the upper limit of the pull-up resistor is limited by the input currents and the input capacitance.

#### CMOS-to-ALSTTL INTERFACE

The output logic level of CMOS devices are completely compatible with the input logic levels of ALSTTL devices. The interface structure with ALSTTL is shown in Figure 30. As with the other CMOS-to-TTL interfaces, there is no pull-up resistor required. The fan-out of ALSTTL devices is determined by the amount of current that flows through Q3 into the

CMOS device, and the amount of current the CMOS device can sink. When the input of the ALSTTL device is low, there is 0.1 mA flowing through Q2. The maximum current that the CMOS device can sink (according to the parameters) is 4 mA. This corresponds to a ALSTTL fan-out of 40.

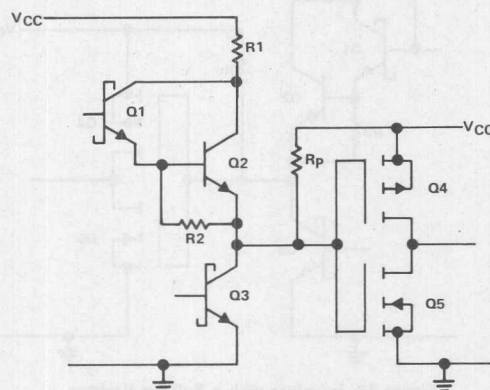


Figure 29. LSTTL to SN54/74HC Interface with a Pull-Up Resistor

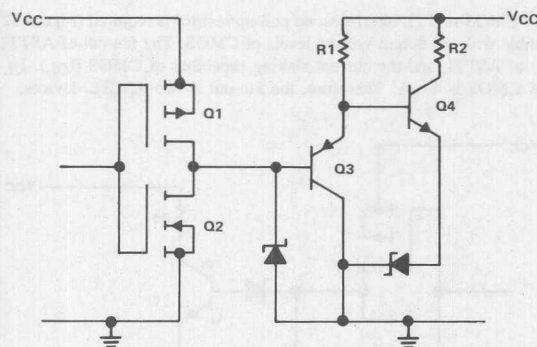


Figure 30. SN54/74HC to ALSTTL Interface

#### ALSTTL-to-CMOS INTERFACE

The high-level output voltage of ALSTTL devices is incompatible with the required high-level input voltage of CMOS devices. Because of this incompatibility, a pull-up resistor is required to make the two voltage levels compatible. The method of determining the upper and lower limits of the pull-up resistor is the same as the other two TTL-to-CMOS interfaces. Figure 31 shows a schematic of the interface.

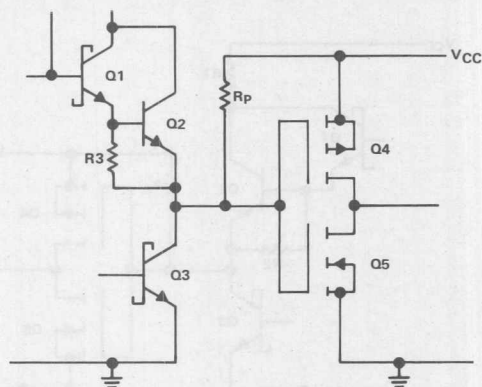


Figure 31. Interface with a Pull-Up Resistor

## CMOS-to-ASTTL INTERFACE

As in the case of the other CMOS-to-TTL interfaces, no pull-up resistor is required (Figure 32) because the input voltage levels of ASTTL are compatible with the output voltage levels of CMOS. The fan-out of ASTTL devices is limited by the low-level input current ( $I_{IL}$ ) of ASTTL and the current sinking capability of CMOS ( $I_{OL}$ ).  $I_{IL}$  for the ASTTL is 2 mA, and the current sink limit of CMOS is 4 mA. Therefore, the fan-out is two ASTTL devices.

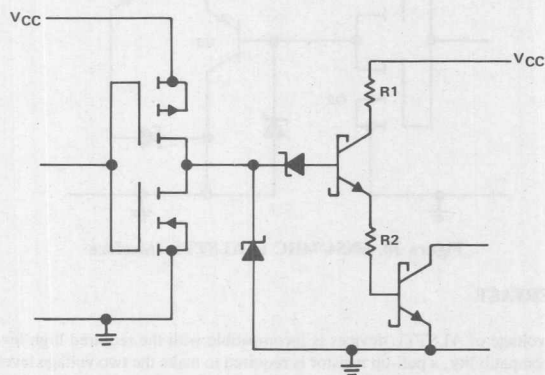


Figure 32. SN54/74HC to ASTTL Interface

## ASTTL-to-CMOS INTERFACE

Not all the output logic levels of ASTTL are compatible with the input logic levels of CMOS. Table 3 shows there is incompatibility between the  $V_{OH}$  of ASTTL and  $V_{IH}$  of CMOS. As with other TTL-to-CMOS interfaces, a pull-up resistor is required (Figure 33). The appropriate value of the pull-up resistor is determined by the same procedure previously explained.

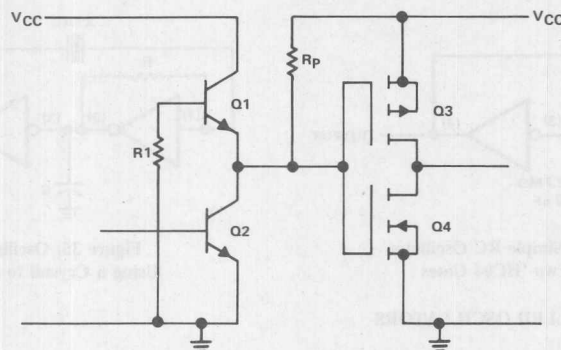


Figure 33. ASTTL to SN54/74HC Interface with a Pull-Up Resistor

### CMOS-to-NMOS INTERFACE

NMOS is used extensively in large-scale-integration products such as microprocessors, microcomputers, and memories. The logic levels of NMOS are usually TTL-compatible. CMOS devices can drive NMOS devices with no pull-up resistors. The input impedance of NMOS is very high, which is similar to the input impedance of CMOS.

### NMOS-to-CMOS INTERFACE

A pull-up resistor may be necessary when an NMOS device drives a CMOS device. The method of determining the value range of the pull-up resistor is the same as the method described previously for TTL. A quick look at NMOS output parameters and CMOS input parameters will determine if a pull-up resistor will be required.

### USING HCT DEVICES TO INTERFACE TO CMOS FROM TTL

To interface from a TTL system (standard TTL, LSTTL, ASTTL, ALSTTL), there are two methods: (1) the use of pull-up resistors (as previously described) and (2) the use of HCT devices. Using HCT devices is by far the easier method. The HCT device inputs are TTL compatible, while the outputs are both TTL and CMOS compatible. Therefore, all the interface requires is to connect the TTL system output into the HCT device, and the output of the HCT device can then be used for the input of the CMOS system.

## Oscillators

### RC OSCILLATORS

Simple oscillator circuits using a minimum number of components can be designed with high-speed CMOS devices, e.g., two 'HC04, 'HCU04, 'HC00, or 'HC02 gates. These oscillators generate a period of approximately  $1.8 RC$  seconds (Figure 34).

### CRYSTAL-CONTROLLED OSCILLATORS

A crystal or ceramic resonator may be used to set the oscillator period (Figure 35). The value of the resistor, typically 100 k $\Omega$ , may require special selection to ensure oscillation at the desired fundamental resonator frequency. The capacitor, typically 100 pF, is required to dampen parasitic oscillations in the 30-MHz to 50-MHz range.

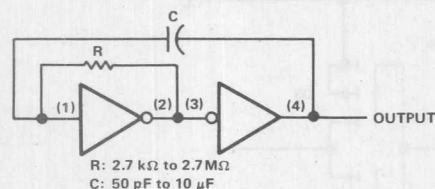


Figure 34. Simple RC Oscillator  
Using Two 'HC04 Gates

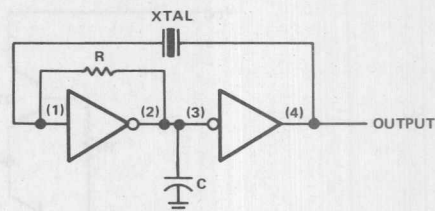


Figure 35. Oscillator Circuit  
Using a Crystal to Set the Period

#### VOLTAGE-CONTROLLED OSCILLATORS

Voltage-controlled oscillators (VCOs) can also be designed using a minimal number of components. Figure 36 shows a VCO using NAND and inverter gates. This VCO design exploits the phenomena of the slight variations in the propagation delay of an 'HC gate with changes in the supply voltage. The 'HC00 is connected as a three-stage ring oscillator with a buffer. As the control (supply) voltage  $V_C$  is varied, the ring oscillator's frequency changes according to the following:

$$f_{out} \approx 5.8 \times V_C$$

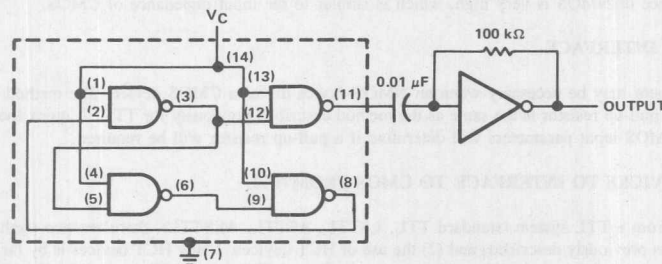


Figure 36. Voltage-Controlled Oscillator (VCO)

The inverter, which is powered by a separate voltage source, serves to restore the oscillator output voltage to 5 V peak-to-peak. This function is required, because the 'HC00 switches from rail-to-rail (as do all HC devices). The magnitude of the oscillator output voltage is thus dependent on  $V_C$ . The 100-kΩ resistor across the inverter provides bias such that operation will be within the linear operating region of the gate. The capacitor serves to ac-couple the oscillator to the inverter.

The VCO output is linear for control voltages in the range of 1.5 to 4.5 V (Figure 37).

To prevent oscillator "bleed-through" onto the  $V_{CC}$  line, adequate decoupling of the 'HC device power supply is required.



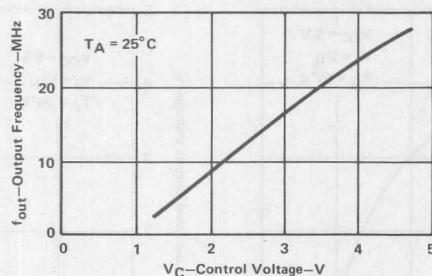


Figure 37. VCO Output Frequency vs Input Voltage

## Drivers for LEDs and Relays

### INTRODUCTION

SN54/74HC devices are capable of sinking or sourcing up to 25 mA (35 mA for high-current devices) per gate. As the device sinks or sources more current,  $V_{OHmin}$  or  $V_{OLmax}$  levels will begin to fall or rise respectively.

Because of these characteristics, SN54/74HC devices can be used to drive LEDs and relays.

### DRIVING LEDs

Figure 38 shows an 'HC04 driving a TIL221 gallium phosphide light-emitting diode. The resistor performs the function of current limiter. The luminous intensity of the LED depends on the amount of forward current.

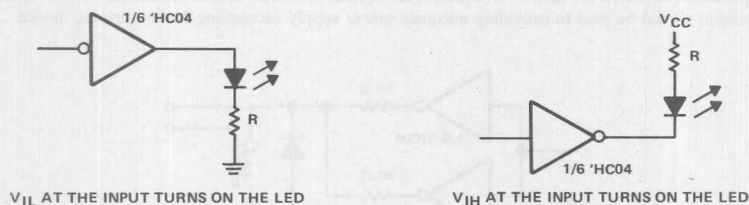


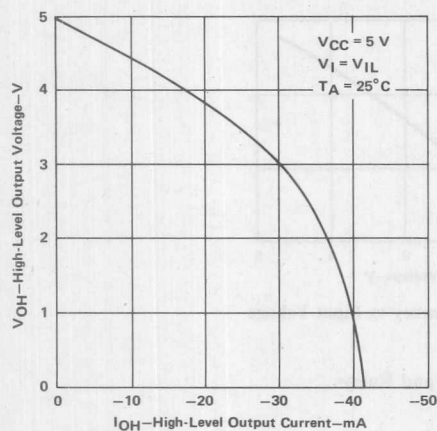
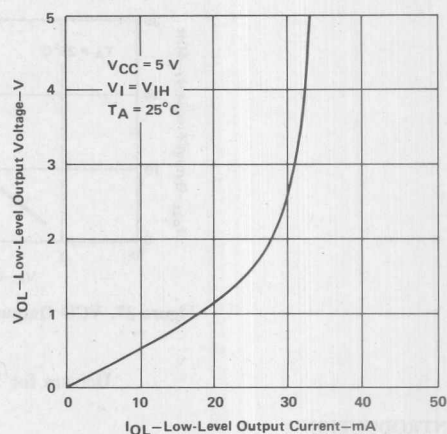
Figure 38. 'HC04 Driving a LED

Example: Using 10 mA forward current and 2.2 V forward voltage, the value of the current-limiting resistor can be calculated using the following equations:

$$\text{[for Figure 38(a)] } R = \frac{V_{OH} - 2.2 \text{ V}}{10 \text{ mA}}$$

$$\text{[for Figure 38(b)] } R = \frac{V_{CC} - 2.2 \text{ V} - V_{OL}}{10 \text{ mA}}$$

It should be noted that as used here,  $V_{OH}$  and  $V_{OL}$  are not the  $V_{OHmin}$  and  $V_{OLmax}$  specified in the data book. Figures 39 and 40 show typical values for  $V_{OH}$  and  $V_{OL}$  for an 'HC00.

Figure 39. Typical Values for  $V_{OH}$ Figure 40. Typical Values for  $V_{OL}$ 

### DRIVING RELAYS

Multiple gates can be connected in parallel to increase the current sinking or sourcing capability of SN54/74HC devices. Figure 41 shows two 'HC04 gates connected in parallel for relay driver application.

Precautions should be taken to prevent one gate from "hogging" the current. Small resistors (typically 50  $\Omega$ ) in series with the output gate will limit the possibility of "current hogging" by any one gate.

In all applications in which the SN54/74HC output is required to source or sink substantial current (6 mA to 25 mA), particular attention should be paid to providing adequate power supply decoupling for the driving device.

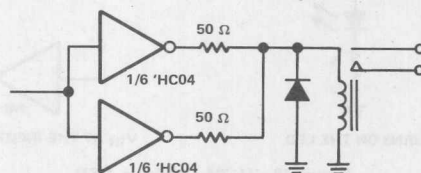


Figure 41. SN54/74HC04 Gates Connected in Parallel to Drive a Relay

### SN54HC/SN74HC Interchangeability Guide

#### INTRODUCTION

The following has been prepared as a guide to interchanging devices from other logic families, both bipolar and CMOS, with those from the SN54HC/SN74HC family. This is not intended to be a comprehensive guide since interchangeability can depend on many factors, and only careful data sheet comparisons can provide definitive answers. The considerations listed below are based upon information accumulated in answering a large number of inquiries in this area.

First, a brief review is given on each logic technology, and second, discussion is given on the various aspects involved in attempting to interchange that technology with the SN54HC/SN74HC family.

## **TTL: Transistor-Transistor Logic**

TTL is the generic name for several bipolar families that have evolved over the past 20 years. Low-Power Schottky (LSTTL) is the most widely used bipolar logic family today. Other families, e.g., Schottky (STTL), Advanced Schottky (ASTTL or AS), and Advanced Low-Power Schottky (ALSTTL or ALS) are also used, depending on the speed versus power performance required by a given system design.

## **4000 Series: Metal-Gate CMOS Logic**

The device type numbers in this series have a variety of prefixes, although "CD" is probably the most widely recognized. The suffix "B" is frequently used, indicating an improvement over the original family, i.e., buffered outputs and typical output sink and source current capabilities of  $\pm 1$  mA. This logic family became popular because it offered very low power consumption, even though it is slower than TTL with a typical operating frequency of about 5 MHz, has a low level of ESD protection, and is latch-up prone.

## **40H00 Series: Metal-Gate CMOS Logic**

This series was designed to overcome the speed limitations of the original 4000 family. Even though these devices are somewhat faster, they are still slow when compared to LSTTL.

## **74C00 Series: Metal-Gate CMOS Logic**

The distinguishing feature of this family is that the pinouts correspond to those of TTL, making interchangeability easier. The devices, however, exhibit many of the same speed/power limitations as those of the 4000 series. The fan-out is typically higher than the 4000 series, however, with typical output sink and source capabilities of  $\pm 1.75$  mA.

## **74SC00 Series: Silicon-Gate CMOS Logic**

This series was the forerunner to the SN54HC/SN74HC family, or more closely, to the SN54HCT/SN74HCT family. The 74SC family was designed to overcome many of the 4000 series deficiencies, particularly the slower speed and the lower drive capability.

Note: The "SC" designation should not be confused with that of Texas Instruments new Standard Cell family (SN54SC/SN74SC series).

## **INTERCHANGEABILITY CONSIDERATIONS**

Listed below are the highlights of benefits derived from replacing other logic families with SN54HC/SN74HC; also listed are important considerations that may affect the feasibility or desirability of such replacement. All comparisons are by necessity general in nature.

### **LSTTL**

#### **Considerations:**

1. SN54HC/SN74HC high-level input voltage is not TTL-compatible. In a mixed family system (LS output driving HC input) it will be necessary to use SN54HCT/SN74HCT, pull-up resistors, or level shifters.
2. SN54HC/SN74HC has less drive capability than some LSTTL functions.
3. LSTTL open-collector outputs have higher breakdowns than SN54HC/SN74HC open-drain equivalent functions.

#### **HCMOS advantages:**

1. Lower system power consumption
2. Improved noise immunity
3. Wider supply voltage range.

**Other TTL Families****Considerations:**

1. SN54HC/SN74HC high-level input voltage is not TTL-compatible. In a mixed family system (TTL output driving HC input) it will be necessary to use SN54HCT/SN74HCT, pull-up resistors, or level shifters.
2. SN54HC/SN74HC has less drive capability than some TTL functions.
3. TTL open-collector outputs have higher breakdowns than SN54HC/SN74HC open-drain equivalent functions.
4. Some of the TTL families offer greater operating speed, e.g., STTL, AS, and ALS.

**HCMOS advantages:**

1. Lower system power consumption
2. Improved noise immunity
3. Wider supply voltage range.

**4000 Series and 74C00 Series****Considerations:**

1. Although most applications use a 5-V supply, these older families operate in the 3-V to 15-V range.
2. SN54HC/SN74HC must be operated with a supply voltage in the 2-V to 6-V range.

**HCMOS advantages:**

1. Higher frequency of operation
2. Improved ESD protection and latch-up performance
3. Higher output drive capability.

**40H00 Series****Considerations:**

1. Although most applications use a 5-V supply, this family will operate in the 2-V to 8-V range.
2. SN54HC/SN74HC must be operated with a supply voltage in the 2-V to 6-V range.

**HCMOS advantages:**

1. Higher frequency of operation
2. Improved ESD protection and latch-up performance
3. Higher output drive capability
4. Multiple-sourced family.

As a quick reference guide, Table 4 shows highlights of interchanging other logic families with high-speed CMOS.

**CONCLUSION**

Within the constraints given above, the SN54HC/SN74HC family can be regarded as pin-for-pin equivalents to the other logic families. The rapidly-expanding SN54HC/SN74HC family is ideally suited for system upgrading, system shrinking, or especially, new system design.

**Table 4. Highlights of Interchangeability**

TTL FAMILY (TTL, LSTTL, STTL, ALS, AS)		METAL-GATE CMOS
Power	HCMOS offers lower system power consumption than any of the TTL families.	Power consumption of HCMOS is less than metal-gate CMOS.
Speed	HCMOS operating speed is comparable to LSTTL. Some TTL families (STTL, AS, and ALS) offer greater operating speed.	HCMOS operating speed is much faster than metal-gate CMOS.
Input Voltage	The $V_{IHmin}$ of HCMOS is not compatible with the $V_{OHmin}$ of TTL. In a mixed family system, it is necessary to use 'HCT devices, pull-up resistors, or level shifters.	HCMOS input voltage levels are compatible with metal-gate CMOS outputs only when the power supply voltage for the metal-gate CMOS devices is between 2 V and 6 V.
Output Voltage	The output voltages of HCMOS are TTL-compatible.	HCMOS output voltage levels are compatible with metal-gate CMOS inputs only when the power supply voltage for the metal-gate CMOS devices is between 2 V and 6 V.
Drive Capability	The output current capability of HCMOS is not as large as the TTL family.	HCMOS has a higher current drive capability.
Fan-out (LS devices)	HCMOS has a smaller fan-out to LS devices than the TTL family.	HCMOS has a higher fan-out to LS devices.
Supply Voltage	HCMOS has a wide operating supply voltage range (2 V to 6 V).	Operating supply range of metal-gate is larger than HCMOS (from 3 V to 15 V).
ESD and Latch-Up	TTL family devices are not as vulnerable to ESD and latch-up damage.	HCMOS has an improved protection circuitry against ESD and latch-up.

### Guidelines for Handling Electrostatic-Discharge Sensitive (ESDS) Devices and Assemblies

#### SCOPE

This specification establishes the requirements for methods and materials used to protect electronic parts, devices, and assemblies (items) susceptible to damage or degradation from electrostatic discharge (ESD). The electrostatic charges referred to in this specification are generated and stored on surfaces of ordinary plastics, most common textile garments, ungrounded people's bodies, and many other commonly unnoticed static generators. The passage of these charges through an electrostatic-sensitive part may result in catastrophic failure or performance degradation of the part.

The part types for which these requirements are applicable include, but are not limited to, those listed:

- 1) All metal-oxide semiconductor (MOS) devices, e.g., CMOS, PMOS, etc.
- 2) Junction field-effect transistors (JFET)
- 3) Bipolar digital and linear circuits
- 4) Op Amps, monolithic microcircuits with MOS compensating networks, on-board MOS capacitors, or other MOS elements
- 5) Hybrid microcircuits and assemblies containing any of the types of devices listed
- 6) Printed circuit boards and any other type of assembly containing static-sensitive devices.

#### Definitions

1. Antistatic material: ESD protective material having a surface resistivity between  $10^9$  and  $10^{14}$   $\Omega$ /square.
2. Static dissipative material: ESD protective material having surface resistivity between  $10^5$  and  $10^9$   $\Omega$ /square.
3. Conductive material: ESD protective material having a surface resistivity of  $10^5$   $\Omega$ /square maximum.

4. Electrostatic discharge (ESD): A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.
5. Surface resistivity: An inverse measure of the conductivity of a material and is the resistance of unit length and unit width of a surface. Note: Surface resistivity of a material is numerically equal to the surface resistance between two electrodes forming opposite sides of a square. The size of the square is immaterial. Surface resistivity applies to both surface and volume conductive materials and has the dimension of  $\Omega/\text{square}$ .
6. Volume resistivity: Also referred to as bulk resistivity. It is normally determined by measuring the resistance (R) of a square of material (surface resistivity) and multiplying this value by the thickness (T).
7. Ionizer: A blower that generates positive and negative ions, either by electrostatic means or by means of a radioactive energy source, in an airstream, and distributes a layer of low velocity ionized air over a work area to neutralize static charges.
8. Close proximity: For the purpose of this specification, is 6 inches or less.

#### Device Sensitivity per Test Circuit of Method 3015, MIL-STD-883

Devices are categorized according to their susceptibility to damage resulting from electrostatic discharge (ESD), and the type packaging required to adequately protect them.

- 1) Device electrostatic sensitivity:

Category	ESD Sensitivity (V)	Minimum Protective Packaging
A	20-2000	Antistatic Magazine & Conductive Bag/Box
B	> 2000	Antistatic Magazine & Antistatic Bag

- 2) Devices are to be categorized by their sensitivity
- 3) Devices are to be protected from ESD damage from receipt at incoming inspection through assembly, test and shipment of completed equipment.

#### APPLICABLE REFERENCE DOCUMENTS

The following reference documents (of latest issue) can provide additional information on ESD controls.

- 1) MIL-M-38510 Microcircuits, General Specification
- 2) MIL-STD-883 Test Methods and Procedures for Microelectronics
- 3) MIL-S-19491 Semiconductor Devices, Packaging of
- 4) MIL-M-55565 Microcircuits, Packaging of
- 5) DOD-HDBK-263 Electrostatic Discharge Control Handbook for Protection
- 6) DOD-STD-1686 Electrostatic Discharge Control Program
- 7) NAVSEA SE 003-11-TRN-010 Electrostatic Discharge Training Manual

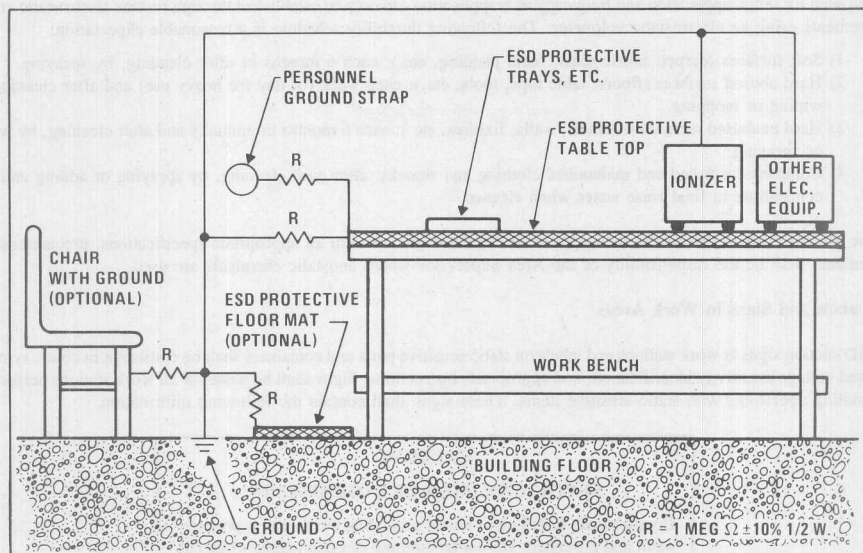
#### FACILITIES FOR STATIC-FREE WORK STATION

The minimum acceptable static-free work station shall consist of the work surface covered with an ESD protective material attached to ground through a  $1 \text{ M}\Omega \pm 10\%$  resistor, an attached grounding wrist strap with integral  $1 \text{ M}\Omega \pm 10\%$  resistor for each operator, and air ionizer(s) of sufficient capacity for each operator. The wrist strap shall be connected to the ESD protective material. Ground shall utilize the standard building earth ground, refer to Figure 42. Conductive floor tile along with conductive shoes may be used in lieu of the conductive wrist straps. The Site Safety Engineer must review and approve all electrical connections at the static-free work station prior to its implementation.

Air ionizers shall be positioned so that the devices at the static-free work stations are within a 4-foot arc measured by a vertical line from the face of the ionizer and 45 degrees on each side of this line.

General grounding requirements are to be in accordance with Table 5.





All electrical equipment sitting on the conductive table top must be hard grounded but must be isolated from the conductive table top.

NOTE: Earth ground is not computer ground or RF ground or any other limited type ground.

Figure 42. Static-Free Work Station

Table 5. General Grounding Requirements

	TREATED WITH ANTISTATIC SOLUTION OR MADE OF CONDUCTIVE MATERIAL	GROUNDING TO COMMON POINT
Handling Equipment/Handtools	X	
Metal Parts of Fixtures and Tools/Storage Racks		X
Handling Trays/Tubes	X	
Soldering Irons/Bath		X
Table Tops/Floor Mats	X	X
Personnel		X Using Wrist Strap*

\*With  $1 \text{ M}\Omega \pm 10\%$  resistor

#### Usage of Antistatic Solution in Areas to Control the Generation of Static Charges

The use of antistatic chemicals (antistats) should be a supplemental part of an overall organized ESD program. Any antistatic chemical application shall be considered as a means to reduce or eliminate static charge generation on nonconductive materials in the manufacturing or storage areas.

The application of any antistatic chemical in a clean room of class 10,000 or less shall not be permitted. Accordingly, any user of antistatic solutions must consider the following precautions:

1. Do not apply antistatic spray or solutions in any form to energized electrical parts, assemblies, panels, or equipment.
2. Do not perform antistatic chemical applications in any area when bare chips, raw parts, packages, and/or personnel are exposed to spray mists and evaporation vapors.

The need for initial application and frequency of reapplication can only be established through routine electrostatic voltage measurements using an electrostatic voltmeter. The following durability schedule is a reasonable expectation.

- 1) Soft surfaces (carpet, fabric seats, foam padding, etc.): each 6 months or after cleaning, by spraying.
- 2) Hard abused surfaces (floors, table tops, tools, etc.): each week (or day for heavy use) and after cleaning, by wiping or mopping.
- 3) Hard unabused surfaces (cabinets, walls, fixtures, etc.): each 6 months or annually and after cleaning, by wiping or spraying.
- 4) Company-furnished and maintained clothing and smocks: after each cleaning, by spraying or adding antistatic concentrate to final rinse water when cleaned.

The use of antistatic chemicals, their application, and compliance with all appropriate specifications, precautions, and requirements shall be the responsibility of the Area Supervisor where antistatic chemicals are used.

#### ESD Labels and Signs in Work Areas

ESD caution signs at work stations and labels on static-sensitive parts and containers shall be consistent in color, symbols, class, and voltage sensitivity identification, and appropriate instructions. Signs shall be posted at all work stations performing any handling operations with static-sensitive items. These signs shall contain the following information.

##### CAUTION

##### STATIC CAN DAMAGE COMPONENTS

Do not handle ESDS items unless grounding wrist strap is properly worn and grounded. Do not let clothing or plain plastic materials contact or come in close proximity to ESDS items.

Labels shall be affixed to all containers containing static-sensitive items at a place readily visible and proper for the intended purpose. Additionally, labels must be consistently placed on containers and packages at a standard location to eliminate mishandling. Use only QC accepted and approved signs and labels to identify static-sensitive products and work areas. The use of ESD signs and labels, and their information content shall be the responsibility of the Area Supervisor to assure consistency and compatibility throughout the static-sensitive routing.

#### Relative Humidity Control

Since relative humidity has a significant impact on the generation of static electricity, when possible, the work area should be maintained within the following relative humidity ranges: incoming/assembly/test/storage 50%-65% (ref. Ashrae, 55-74), within  $\pm 5\%$  to avoid static voltage monitor variations.

#### PREPARATION FOR WORKING AT STATIC-FREE WORK STATION

A work station with a conductive work surface connected to ground through a  $1\text{ M}\Omega \pm 10\%$  resistor, a grounding wrist strap with the ground wire connected to the conductive work surface, and an ionizer constitute a static-free work station (Figure 42). An operator is properly grounded when the wrist strap is in snug (no slack) contact with the bare skin, usually positioned on the left wrist for a right-handed operator. The wrist strap must be worn the entire time an operator is at a static-free work station. The operator should first touch the grounded bench top before handling static-sensitive items. This precaution should be observed in addition to wearing the grounding wrist strap. If possible, operators should avoid touching leads or contacts even though grounded.

##### CAUTION

Personnel shall never be attached to ground without the presence of the  $1\text{ M}\Omega \pm 10\%$  series resistor in the ground wire.

An operator's clothing should never make contact or come in close proximity with static sensitive items. They must be especially careful to prevent any static-sensitive items (being handled) from touching their clothing. Long sleeves must be rolled up or covered with antistatic sleeve protector banded to the bare wrist which shall "cage" the sleeve at least as far up as the elbow. Only antistatic finger cots may be used when handling static-sensitive items.

Any person not properly prepared, while at or near the work station, shall not touch or come in close proximity with any static-sensitive items. It is the responsibility of the operator and the Area Supervisor to ensure that the static-free work area is clear of unnecessary static hazards, including such personal items as plastic coated cups or wrappers, plastic cosmetic bottles or boxes, combs, tissue boxes, cigarette packages, and vinyl or plastic purses. All work-related items, including information sheets, fluid containers, tools, and parts carriers must be those approved for use at the static-free work station.

## GENERAL HANDLING PROCEDURES AND REQUIREMENTS

1. All static-sensitive items must be received in an antistatic/conductive container and must not be removed from the container except at static-free work station. All protective folders or envelopes holding documentation (lot travelers, etc.) shall be made of nonstatic-generating material.
2. Each packing (outermost) container and package (internal or intermediate) shall have a bright yellow warning label attached, stating the following information or equivalent:



The warning label shall be legible and easily readable to normal vision at a distance of 3 feet.

3. Static-sensitive items are to remain in their protective containers except when actually in work at the static-free station.
4. Before removing the items from their protective container, the operator should place the container on the conductive grounded bench top and make sure the wrist strap fits snugly around the wrist and is properly plugged into the ground receptacle, then touch hands to the conductive bench top.
5. All operations on the items should be performed with the items in contact with the grounded bench top as much as possible. Do not allow conductive magazine to touch hard grounded test gear on bench top.
6. Ordinary plastic solder-suckers and other plastic assembly aids shall not be used.
7. In cases where it is impossible or impractical to ground the operator with a wrist strap, a conductive shoe strap may be used along with conductive tile/mats.
8. When the operator moves from any other place to the static-free station, the start-up procedure shall be the same as in PREPARATION FOR WORKING AT STATIC-FREE WORK STATION.
9. The ionizer shall be in operation prior to presenting any static-sensitive items to the static-free station, and shall be in operation during the entire time period the items are at the station.
10. "Plastic snow" polystyrene foam, "peanuts," or other high-dielectric materials shall never come in contact with or be used around electrostatic sensitive items, unless they have been treated with an antistat (as evidenced by pink color and generation of less than  $\pm 100$  volts).
11. Static-sensitive items shall not be transported or stored in trays, tote boxes, vials, or similar containers made of untreated plastic material unless items are protectively packaged in conductive material.

## PACKAGING REQUIREMENTS

Packaging of static-sensitive items is to be in accordance with Device Sensitivity, item 1). The use of tape and plain plastic bags is prohibited. All outer and inner containers are to be marked as outlined in GENERAL HANDLING PROCEDURES AND REQUIREMENTS, item 2, and conductive magazines/boxes may be used in lieu of conductive bags.

## SPECIFIC HANDLING PROCEDURES FOR STATIC-SENSITIVE ITEMS

### Stockroom Operations

1. Containers of static-sensitive items are not to be accepted into stock unless adequately identified as containing static-sensitive items.
2. Items may be removed from the protective container (magazine/bag, etc.) for the purpose of subdividing for order issue only by a properly grounded operator at an approved static-free station as defined in FACILITIES FOR and PREPARATION FOR WORKING AT STATIC-FREE WORK STATION.
3. All subdivided lots must be carefully repackaged in protective containers (magazine/bag, etc.) prior to removal from the static-free work station and labeled to indicate that the package(s) contain static-sensitive items. If it is suspected that a static-sensitive item is not adequately protected, do not transfer it to another container, return it to the originator for disposition unless the originator is a Customer. In that case, the QC Engineer should contact the Customer and negotiate an appropriate disposition.
4. It is the responsibility of the Stockroom Supervisor to ensure that all personnel assigned to this operation are familiar with handling procedures as outlined in this specification. A copy of this specification is to be posted in the vicinity so that it is accessible to the operators. Stock handlers and all others who might have occasion to move stock are to be instructed to avoid direct contact with unprotected static-sensitive items.

### Module and Subassembly Operations

1. Static-sensitive items are not to be received from a stockroom, kitting, or machine insertion area unless received in approved static-protective packaging, and properly labeled to indicate that its contents are static sensitive.
2. All single station, progressive line manual assembly operators, and visual inspectors prior to wave soldering operations are to be properly grounded with a grounding wrist strap when handling static-sensitive items.
3. Progressive lines used as single stations where operators will be working on a mix of boards, both static-sensitive and nonstatic-sensitive, will require that all operators working on the line be properly grounded. This is necessary to accommodate the sliding of static-sensitive boards along the assembly bench or across positions not engaged in the assembly of this type board.
4. It is the responsibility of the Area Supervisor to ensure that all personnel handling static-sensitive items are familiar with this procedure and fully aware of the damage or degradation of these units in the event of noncompliance. A periodic inspection should be made using an electrostatic voltmeter to assure that the static-free stations are in proper working order and to ensure that operators are wearing grounding wrist straps properly (snugly in contact with bare skin).

### Soldering and Lead-Forming Operations

1. All soldering machines, conveyors, cleaning machines, and equipment shall be electrically grounded to ensure that they are at the same ground potential as the grounded operators working on their stations. No machine surfaces exposed to static-sensitive items are to be above the ground potential.
2. All processing equipment shall be grounded, including all loading and unloading stations, that is, the stations before and after each piece of processing equipment.
3. All nonmetallic, static-generating components in the handling systems shall be treated to ensure protection from static.
4. All stations shall be identified by posting signs as outlined in **ESD Labels and Signs in Work Areas**.
5. Operators are to be properly grounded with a grounding wrist strap during any handling, loading, unloading, inspection, rework, or proximity to static-sensitive items.
6. Unloading operators working at a grounded station shall place static-sensitive items into approved static-protective bags or containers.
7. All manual soldering, repair, and touch-up work stations on the solder line are to be static protected. Operators are to wear grounding wrist straps when working on static-sensitive items. Only grounded-tip soldering/desoldering irons are allowed when working on static-sensitive items.
8. It is the responsibility of the Area Supervisor to ensure that all personnel handling static-sensitive items are familiar with this procedure and fully aware of the damage or degradation of these units in the event of noncompliance. A periodic inspection should be made using an electrostatic voltmeter to assure that the static-free stations are in proper working order and to ensure that operators are wearing grounding wrist straps properly (comfortably snug in contact with bare skin).

### Electrical Testing Operations

1. All electrical test stations shall be static protected. Operators shall be properly grounded when working on these items.
2. Reused antistatic magazines must be monitored for maintenance of antistatic characteristics.
3. Devices should be in an antistatic/conductive environment except at the moment when actually under test.
4. Devices should not be inserted into or removed from circuits or tester with the power on or with signals applied to inputs to prevent transient voltages from causing permanent damage.
5. All unused input leads should be biased if possible.
6. Device or module repairs must be performed at static-free stations with the operator attached to a grounding wrist strap. Grounded-tip soldering irons shall be used when working on static-sensitive items.
7. Static-sensitive items shall be handled through all electrical inspections in static protective containers. Removal of the items from the protective containers shall be done at a static-free work station as discussed in **PREPARATION FOR WORKING AT A STATIC-FREE WORK STATION**. The units must be returned to the containers before leaving the station.
8. All such items shall be shipped with an ESD warning label affixed as listed.
9. It is the responsibility of the Area Supervisor to ensure that all personnel handling static-sensitive items are familiar with this procedure and fully aware of the damage or possible degradation of these units in the event of noncompliance. A periodic inspection should be made using an electrostatic voltmeter to assure that the static-free stations are in proper working order and to ensure that operators are wearing grounding straps properly (snugly in contact with bare skin).

### Packing Operations

1. Static-sensitive items are not to be accepted into the packing area unless they are contained in a static-protected bag or conductive container.
2. A static-sensitive item delivered to the packer within an approved container or bag and found to be in order regarding identification shall be packed in the standard shipping carton or other regular packaging material. Containers are to be labeled in accordance with **GENERAL HANDLING PROCEDURES AND REQUIREMENTS**, item 2.
3. Any void-fillers shall be made of an approved antistatic material.

### Burn-In Operations

1. Burn-in board loading and unloading of static-sensitive items shall be done at a static-free station.
2. Shorting clips/shorted connectors shall be installed on the board plug-in tab prior to loading any units into the board sockets. The clip/connector shall be taken off just prior to plugging the board into the oven connector. The clip/connector shall be installed immediately upon removal of the board from the oven connector. Installation and removal of the clip/connector shall be done by a properly grounded operator.
3. All automatic or semiautomatic loading and unloading equipment shall be properly electrically grounded.
4. It is the responsibility of the Area Supervisor to ensure that all personnel handling static-sensitive items are familiar with this procedure and fully aware of the damage or possible degradation of these units in the event of noncompliance. A periodic inspection should be made using an electrostatic voltmeter to assure that the static-free stations are in proper working order and to ensure that operators are wearing grounding straps properly (snugly in contact with bare skin).

### CUSTOMER RETURNED ITEM HANDLING PROCEDURE

Receipt of ESDS-labeled items is to be done at a static-free work station and handled in accordance with applicable sections within this guideline.

### QUALITY CONTROL PROVISIONS

#### Sampling

Each manufacturing, stockroom, and testing operation handling ESDS devices will be audited a minimum of once each quarter for compliance with all terms of this specification by the responsible process control or QRA organization. Ground continuity and the presence of uncontrolled static voltages are considered critical and shall be checked more frequently as specified below.



**Ground Continuity (minimum of once a week).**

Ground connections (grounding wrist strap, ground wires on cords, etc.) shall be checked for electrical continuity. The presence of a  $1\text{ M}\Omega \pm 10\%$  resistor in the ground connections between both the operator wrist straps to the work surface and the work surface to ground connector must be verified.

**Grounded Conditions (minimum of once a week).**

A visual inspection shall be made to determine full compliance with this specification at static-free work stations during handling of static-sensitive items, including operator being grounded as required, static-sensitive items not being handled in unprotected or unauthorized areas, and no static-generating materials at the grounded work station.

**Sleeve Protectors (minimum of once a week).**

A visual check shall be made to determine that each operator wearing loose-fitting or long-sleeved clothing either has sleeves properly rolled or covered with sleeve protectors properly grounded to the bare skin at the wrist.

**Static Voltage Levels (minimum of once a week).**

In addition to the visual inspections, a sample inspection using an electrostatic voltmeter will be used to check for uncontrolled electrostatic voltages at or near electrostatic-controlled work stations.

**Conductive Floor Tiles (minimum of once a month).**

Conductive floors must have a resistance of not less than  $25\text{ k}\Omega$  from any point on the tile to earth ground. Also, resistance from any point-to-point on the tile floor 3 feet apart shall be not less than  $25\text{ k}\Omega$ . The test methods to be used are ASTM-F-150-72 and NFPA 56.

**Records**

Written records must be kept of all these QC audits.

**TRAINING**

Training is applicable for all areas where individuals come in contact with ESDS (category A) devices. It is the responsibility of each Area Supervisor to make sure that his/her people receive ESD training initially and every 12 months thereafter to maintain proficiency. Training should include static fundamentals, a review of applicable parts of this specification, and actual applications in the work area.



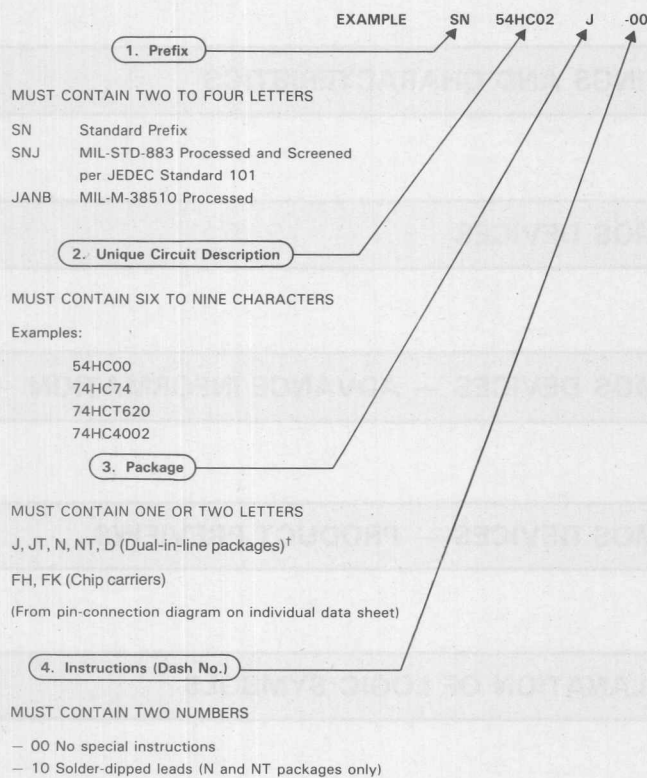
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**GENERAL INFORMATION****1****RATINGS AND CHARACTERISTICS****2****HCMOS DEVICES****3****HCMOS DEVICES — ADVANCE INFORMATION****4****HCMOS DEVICES — PRODUCT PREVIEWS****5****EXPLANATION OF LOGIC SYMBOLS****6****DESIGNERS' INFORMATION****7****MECHANICAL DATA****8****QUALITY AND RELIABILITY****9**

## ORDERING INSTRUCTIONS

Electrical characteristics presented in this data book, unless otherwise noted, apply for circuit type(s) listed in the page heading regardless of package. The availability of a circuit function in a particular package is denoted by an alphabetical reference above the pin-connection diagram(s). These alphabetical references refer to mechanical outline drawings shown in this section.

Factory orders for circuits described in this catalog should include a four-part type number as explained in the following example.



<sup>†</sup> These circuits in dual-in-line packages are shipped in one of the carriers shown below. Unless a specific method of shipment is specified by the customer (with possible additional costs), circuits will be shipped in the most practical carrier. Please contact your TI sales representative for the method that will best suit your particular needs.

Dual-in-line J, JT, N, NT, D (= SO)

- Slide Magazines
- A-Channel Plastic Tubing
- Barnes Carrier (N only)
- Sectioned Cardboard Box
- Individual Plastic Box

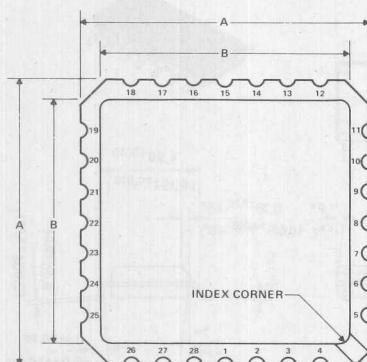
## FH and FK ceramic chip carrier packages

Both versions of these hermetically sealed chip carrier packages have ceramic bases. The FH package is an all-ceramic package with a glass seal. The FK package has a three-layer base with a metal lid and braze seal.

The packages are intended for surface mounting on solder lands on 1,27 (0.050) centers. Terminals require no additional cleaning or processing when used in soldered assembly.

FH and FK package terminal assignments conform to JEDEC Standards 1 and 2.

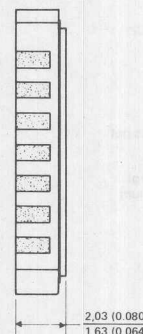
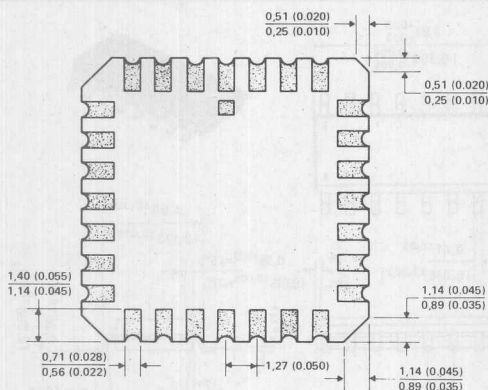
FH AND FK CERAMIC CHIP CARRIER PACKAGES  
(28-terminal package shown)



CERAMIC CHIP CARRIERS

JEDEC OUTLINE DESIGNATION*	NO. OF TERMINALS	A		B	
		MIN	MAX	MIN	MAX
MS004CB	20	8,69 (0.342)	9,09 (0.358)	7,80 (0.307)	9,09 (0.358)
MS004CC	28	11,23 (0.442)	11,63 (0.458)	10,31 (0.406)	11,63 (0.458)

\*All dimensions and notes for the specified JEDEC outline apply.



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

## MECHANICAL DATA

### D plastic dual-in-line packages (SO package)

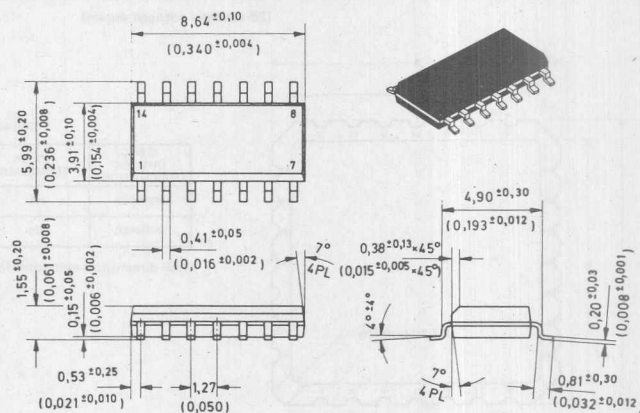
Each of these dual-in-line packages consists of a circuit mounted on a lead frame and encapsulated within a plastic compound. The compound will withstand soldering temperature with no deformation, and circuit performance characteristics will remain stable when operated in high-humidity conditions. Leads require no additional cleaning or processing when used in soldered assembly.

#### 14-PIN D PACKAGE

##### NOTES:

1. Body dimensions do not include mold flash.
2. Leads are within 0,25 (0,010) radius of true position at maximum material condition.

ALL DIMENSIONS ARE IN MILLIMETERS  
AND PARENTHESTICALLY IN INCHES

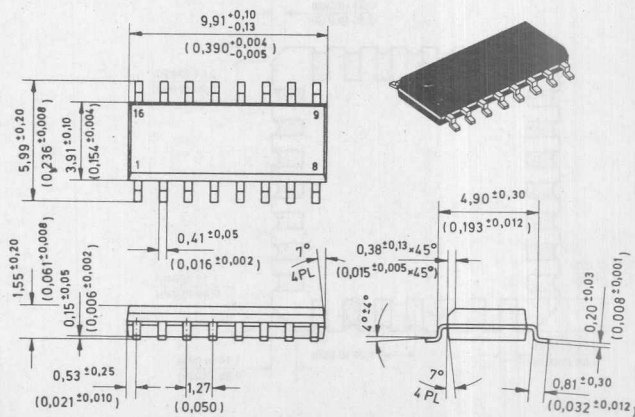


#### 16-PIN D PACKAGE

##### NOTES:

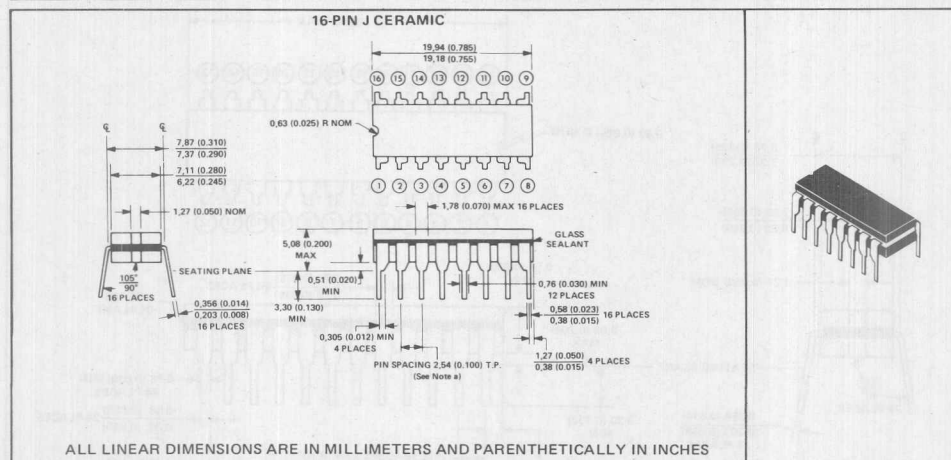
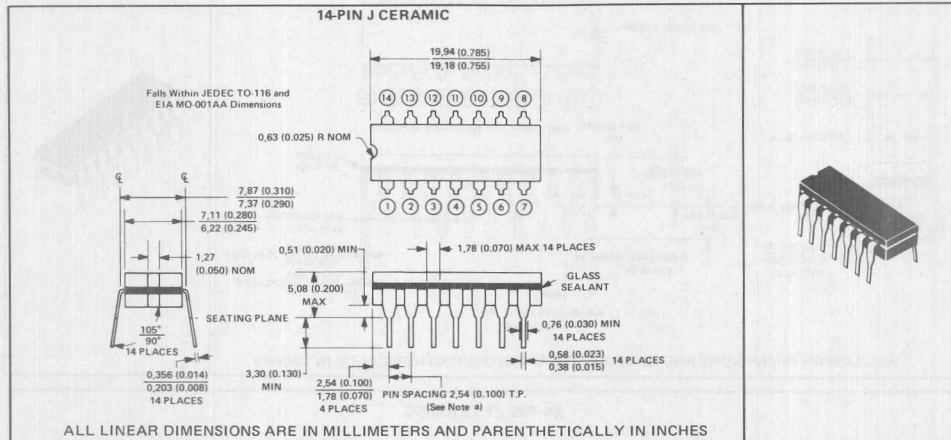
1. Body dimensions do not include mold flash.
2. Leads are within 0,25 (0,010) radius of true position at maximum material condition.

ALL DIMENSIONS ARE IN MILLIMETERS  
AND PARENTHESTICALLY IN INCHES



**J ceramic packages (including JT packages)**

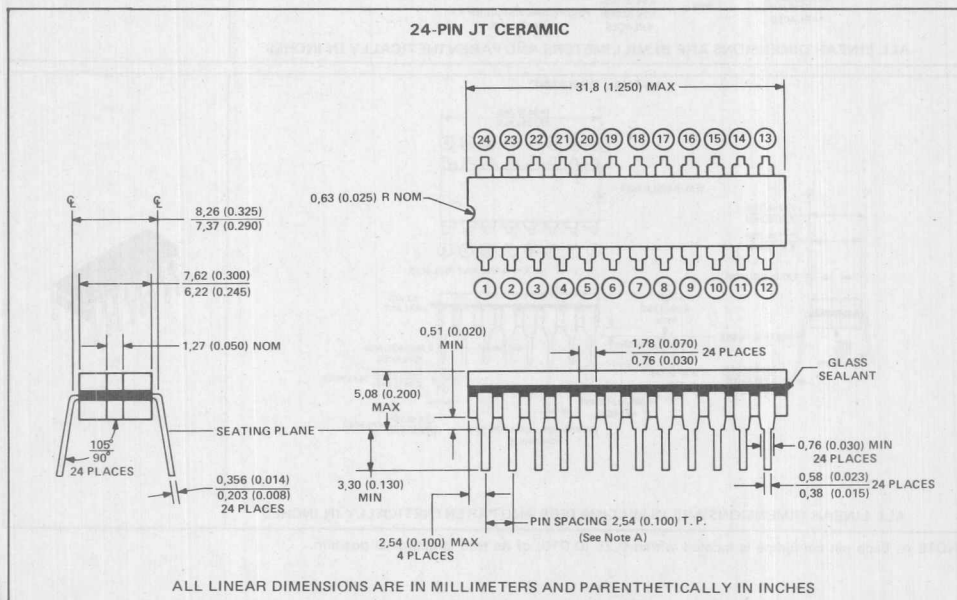
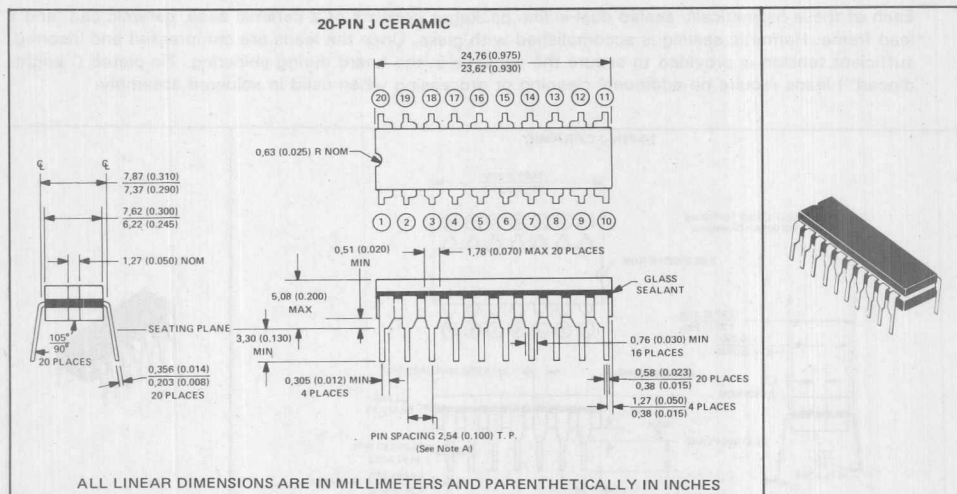
Each of these hermetically sealed dual-in-line packages consists of a ceramic base, ceramic cap, and a lead frame. Hermetic sealing is accomplished with glass. Once the leads are compressed and inserted, sufficient tension is provided to secure the package in the board during soldering. Tin-plated ("bright-dipped") leads require no additional cleaning or processing when used in soldered assembly.



NOTE A: Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

## MECHANICAL DATA

### J ceramic dual-in-line packages (continued)



NOTE A: Each pin centerline is located within 0.25 (0.010) of its true longitudinal position.

MECHANICAL DATA

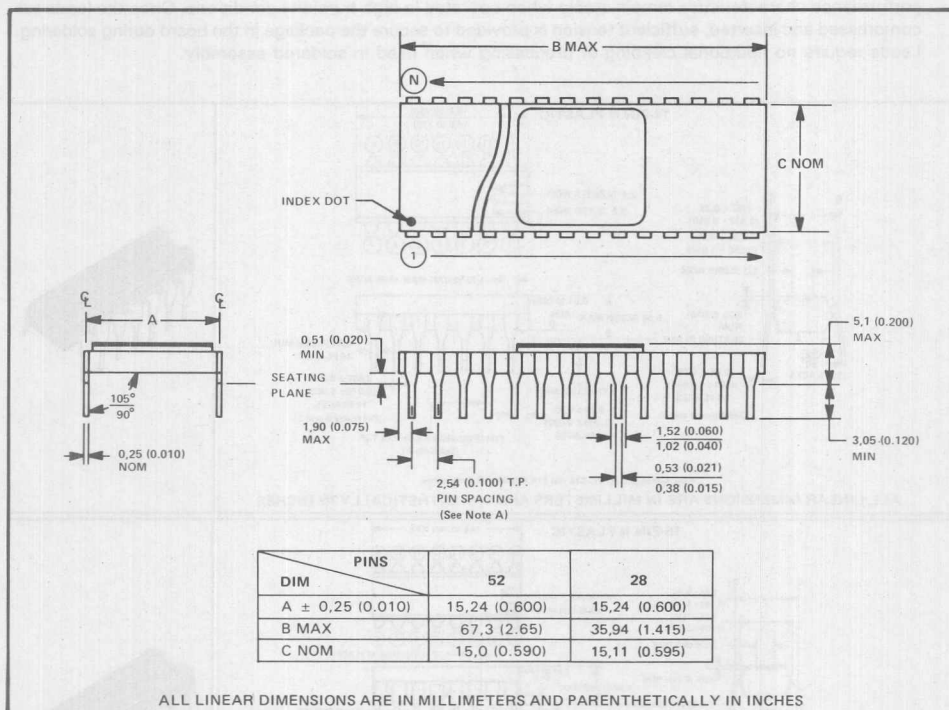
8



## MECHANICAL DATA

### JD ceramic dual-in-line packages — side-braze

This is a hermetically sealed ceramic package with a metal cap and side-brazed tin-plated leads.



NOTE A: Each pin centerline is located within 0,25 (0,010) of its true longitudinal position.

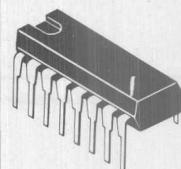
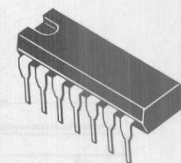
MECHANICAL DATA

8

## MECHANICAL DATA

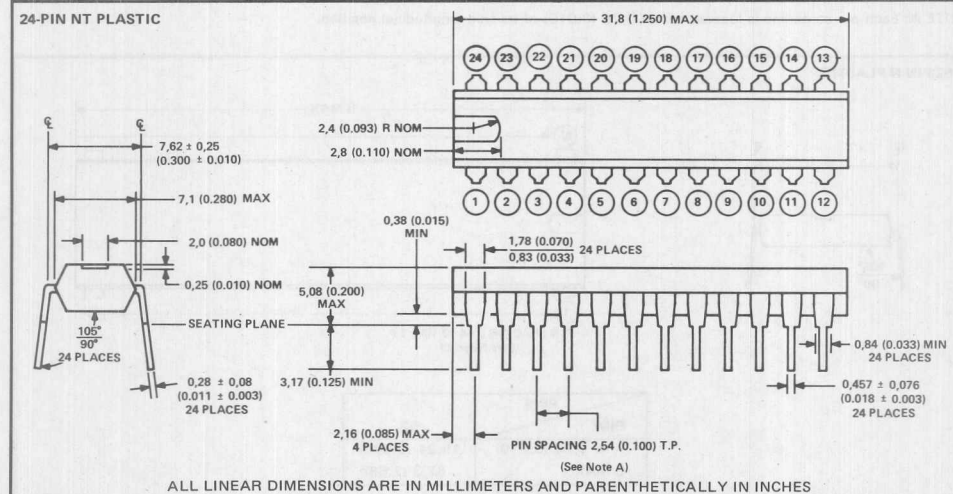
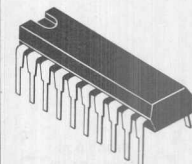
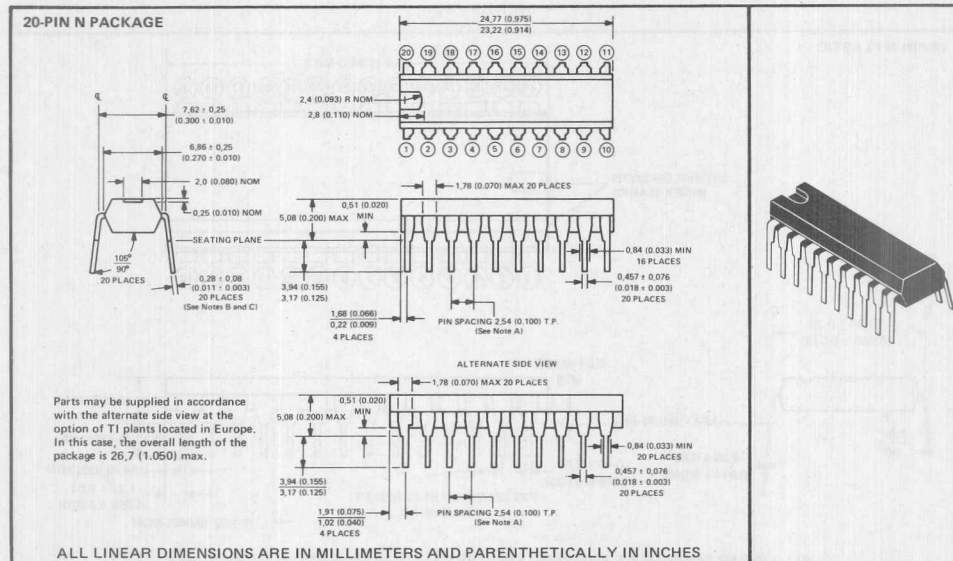
## 8

NOTES: A. Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.  
B. This dimension does not apply for solder-dipped leads.  
C. When solder-dipped leads are specified, dipped areas of the lead extends from the lead tip to at least 0,51 (0.020) above seating plane.



NOTES: A. Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.  
B. This dimension does not apply for solder-dipped leads.  
C. When solder-dipped leads are specified, dipped areas of the lead extends from the lead tip to at least 0,51 (0.020) above seating plane.

## N plastic dual-in-line packages (continued)

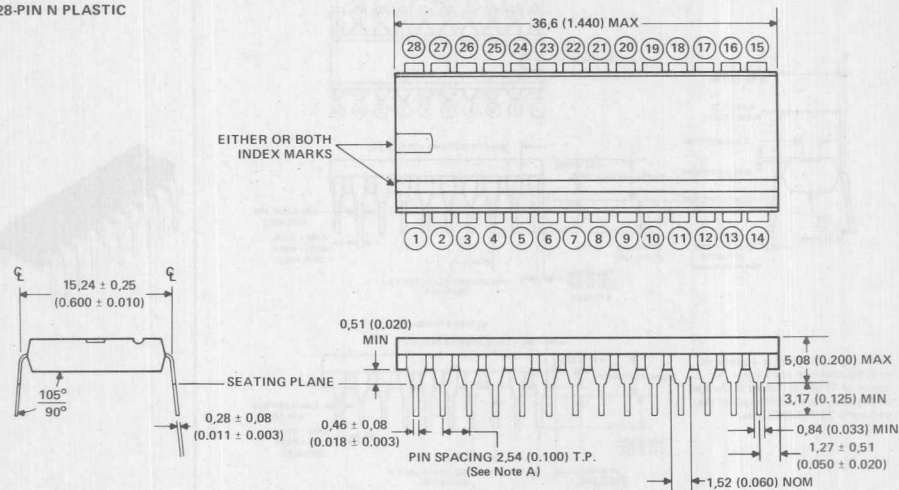


- NOTES: A. Each pin centerline is located within 0.25 (0.010) of its true longitudinal position.  
 B. This dimension does not apply for solder-dipped leads.  
 C. When solder-dipped leads are specified, dipped areas of the lead extends from the lead tip to at least 0.51 (0.020) above seating plane.

## MECHANICAL DATA

### N plastic dual-in-line packages (continued)

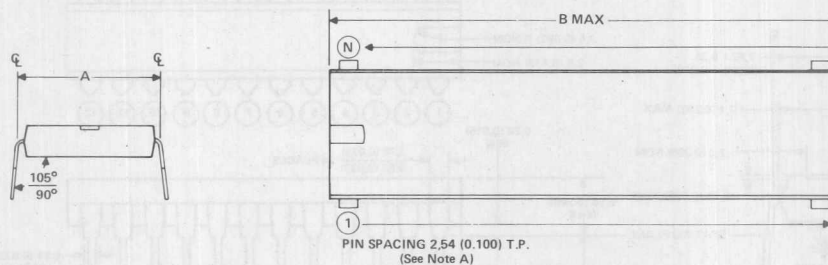
#### 28-PIN N PLASTIC



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

NOTE A: Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

#### 52-PIN N PLASTIC



PINS	
DIM	52
A ± 0,25 (0.010)	15,24 (0.600)
B MAX	67,3 (2.65)

ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

NOTE A: Each pin centerline is located within 0,25 (0.010) of its true longitudinal position.

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## INTRODUCTION

With the development of High-speed Silicon-gate CMOS products at Texas Instruments Incorporated, the approach is to develop quality and reliability standards that make this product family the leader in the industry. Stringent quality and reliability performance and manufacturing standards are defined prior to product design to assure this leadership objective. In addition, the following product/process qualifications and evaluations are performed to assure that these standards are met on every device released to the market:

- Verification of manufacturability through testing of bar compatibility with piece parts and automated assembly techniques and equipment
- Proof of process repeatability through definition of minimum acceptable assembly and test yields
- Testing to data sheet limits through test program certification and guard-bands between probe, final test, and QRA final acceptance
- Assurance of quality performance through a comprehensive statistical process control program coupled with tight product acceptance standards
- Assessment of device reliability performance through an extensive reliability test and qualification program

## DESIGN TO QUALITY AND RELIABILITY

The most reliable and cost effective method to assure the quality and reliability of a product is to design and build it in rather than test or screen for it. With this concept in mind the designers develop batteries of test bar structures to verify the integrity of the designs. Two such examples of designed-in features that affect quality and reliability are the development of excellent latch-up protection and electrostatic discharge protection circuits.

## LATCH-UP

Latch-up is the uncontrolled flow of current through the parasitic thyristors inherent in all CMOS devices (see Figure 1). The current path is generally between the  $V_{CC}$  and ground pins of the IC and can be triggered by excessive currents in the signal pins or by  $di/dt$  stress of the  $V_{CC}$  pin. Once the thyristor is triggered, the current flow is limited only by the impedance of the power supply and will generally result in the destruction of the affected device. Latch-up is more likely to occur at high supply voltages and high temperatures.

The conditions permitting latch-up exist whenever the gain product of the parasitic n-p-n and p-n-p transistors forming the thyristor exceeds unity. In the Texas Instruments P-well CMOS process, the gain of the vertical n-p-n transistor formed by N+ source/drain, N-well, and N-substrate is high and although the lateral p-n-p formed by P+ source/drain, N-substrate, and P-well is low, the product of the two gains exceeds unity.

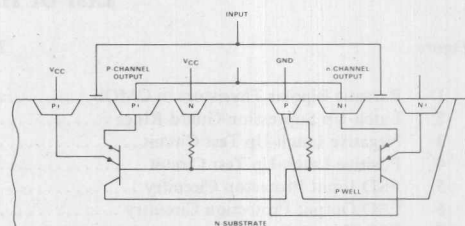


Figure 1. Parasitic Bipolar Thyristors in CMOS

To minimize latch-up, TI uses extensive guard-ring structures (see Figure 2) in the design of the IC to shunt potential latch-up currents to  $V_{CC}$  and ground before they appear as base currents in the parasitic transistor. The guard-rings are N+ and P+ diffused regions placed between the N+ and P+ source/drains and electrically connected to  $V_{CC}$  or ground. This raises the parasitic thyristors' trigger point to a current level much higher

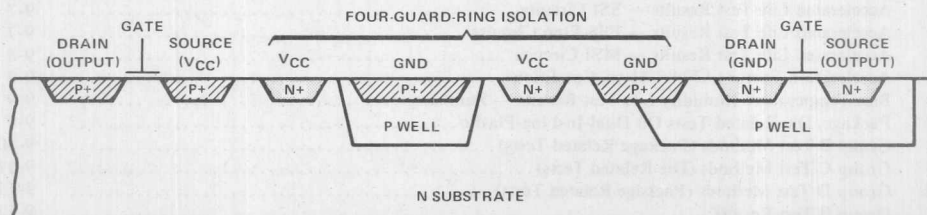


Figure 2. Latch-Up Suppression Guard Rings

applied by typical signals. Extensive tests have shown a device resistance to latch-up ranging from 450  $\Omega$  greater than 1 A at 25°C, and consistently greater than 250  $\Omega$  at 125°C. TI does not release a device design to production until it demonstrates protection against at least 100 mA latch-up currents at 125°C.

To test the latch-up protection circuitry in the High-speed CMOS logic family, TI uses the circuits illustrated in Figures 3 and 4. For testing negative latch-up (see Figure 3), the device  $V_{CC}$  is connected to a 5-V, 1-A power supply through a 10- $\Omega$ , 5-W resistor. A 10- $\Omega$  resistor is placed across the power supply terminals to provide current sinking capability. For testing positive latch-up (see Figure 4), the device  $V_{CC}$  is connected to ground and the device ground is connected to a -5-V, 1-A power supply through a 10- $\Omega$ , 5-W resistor. Again a 10- $\Omega$  resistor is placed across the terminals of the power supply to provide current sinking capability. In both cases the pin under test (P.U.T.) is connected to a variable-voltage pulse generator through a 25- $\Omega$ , 10-W resistor.

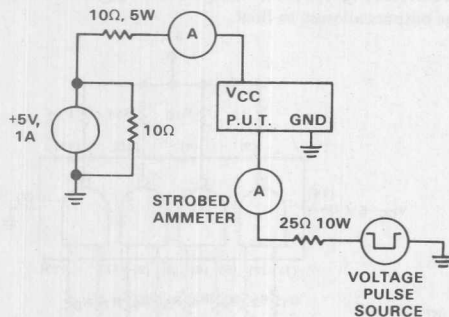


Figure 3. Negative Latch-Up Test Circuit

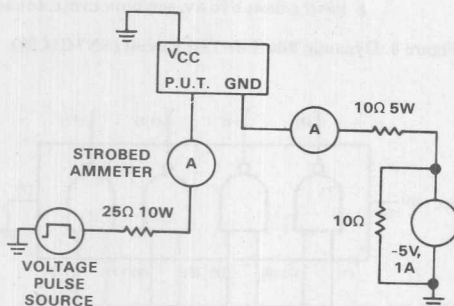


Figure 4. Positive Latch-Up Test Circuit

To test the output protection circuitry for positive latch-up, all the inputs are biased so that only the output pin under test is high. For negative latch-up testing, the inputs are biased so that only the output pin under test is low (see Figures 3 and 4). Using the pulse generator, a 5.5-V pulse (-0.5 V for negative latch-up testing) of 100- $\mu$ s duration is applied to the output pin under test. After the 100- $\mu$ s pulse, the output pin under test should be returned to its initial state (5 V for positive latch-up testing, 0 V for negative latch-up testing) for 900  $\mu$ s. If the supply current exceeds 200 mA during this 900- $\mu$ s period, then the device is considered to have latched-up. The current at which latch-up occurs is the current measured by the strobbed ammeter on the last pulse. If the device has not latched-up, then the pulse generator voltage is increased by 0.5 V (by -0.5 V for negative latch-up testing) and the procedure is repeated.

To test the input protection circuitry for positive latch-up, all the inputs except the input under test are biased at 0 V. For negative latch-up testing, all the inputs except the input under test are biased at 5 V. The procedure used to test the inputs is the same as the output latch-up testing previously described.

Although the High-speed CMOS logic family has been designed to be insensitive to latch-up, it is recommended as a good design practice to minimize external trigger conditions. The  $dv/dt$  at the  $V_{CC}$  pin can be minimized by the addition of a capacitor across the  $V_{CC}$  and ground pins in close physical proximity to the IC package. Excessive input and output currents can be minimized by design techniques that limit input and output voltage swings beyond the supply rails.

## ELECTROSTATIC DISCHARGE PROTECTION CIRCUITS

The electrostatic discharge (ESD) protection circuit for the High-speed CMOS logic family uses a combination of P+ and N+ diode clamps to the supply rails and a series N+ resistor for input gate protection as illustrated in Figure 5.

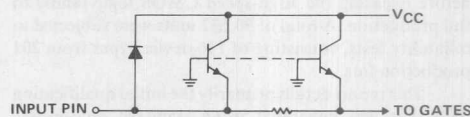


Figure 5. ESD Input Protection Circuitry

The outputs are protected by the P+ and N+ drain diodes of the output transistors and an additional P+ diode clamped to  $V_{CC}$  as illustrated in Figure 6.

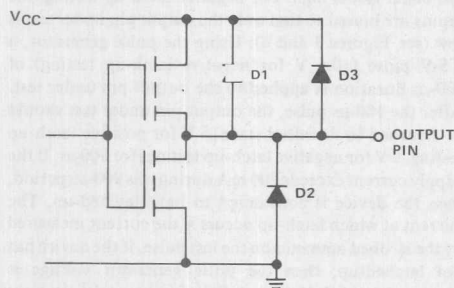


Figure 6. ESD Output Protection Circuitry

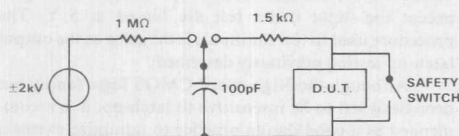


Figure 7. ESD Test Circuit

TI tests the ESD protection circuitry according to the MIL-STD-883 Method 3015. A schematic of the test circuitry is illustrated in Figure 7. The safety switch is closed only when the device under test (D.U.T.) is being inserted or removed. The 100-pF capacitor is charged up to +2000 V and then discharged into the pin under test. This is repeated five times per pin with a five second interval between each discharge. The sequence is then repeated with the capacitor charged up to -2000 V.

## QUALIFICATION TESTING

Texas Instruments completed one of the most extensive qualification testing programs ever designed before releasing the High-speed CMOS logic family to full production. A total of 90,632 units were subjected to reliability tests, consisting of 116 device types from 201 production lots.

This report details primarily the initial qualification data that was generated using standard dual-in-line plastic devices. Devices used in this testing were assembled over a seven month period (date codes 8327 through 8349) and were tested as received from assembly/test facility with no special screens to reduce or eliminate infant mortality.

The accelerated and bias temperature humidity life test results are grouped as defined by the proposed JEDEC JC 40.2 classification for  $I_{CC}$  (Quiescent current). The classification system includes SSI, Flip-Flops and MSI categories. All other test results are presented as a SN74HC product total. Additional testing on other plastic packages is currently underway and will be reported in future publications.

A summary of the qualification data for the SNJ54HC logic family is also provided in this report.

## ACCELERATED LIFE TEST

Accelerated life testing at elevated temperature is performed to simulate long-term operation and develop reliability data to predict field failure rates. The tests were conducted on SN74HC product using both dynamic and static bias techniques with 6 V applied and  $T_A=125^\circ\text{C}$ . Also, a complete functional and  $25^\circ\text{C}$  DC parametric test was done at 0, 96, 500, and 1000 hours. In addition, many samples were extended to a total of 2000 hours.

The dynamic bias life test circuit (see Figure 8) toggles the inputs from 0 to 6 V at 50 kHz. Each output is tied to 3 V through a 2-kΩ resistor. The static bias life test circuit (see Figure 9) sets the inputs and  $V_{CC}$  to 6 V, with the outputs allowed to float.

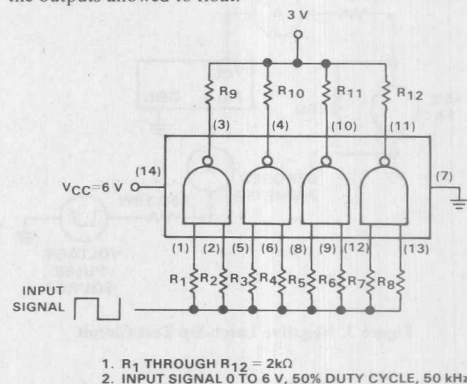


Figure 8. Dynamic Bias Life Test Circuit (SN74HC00)

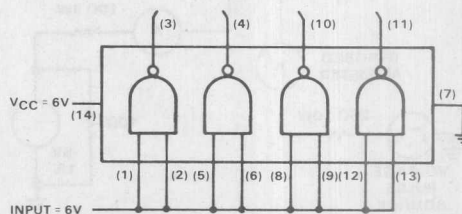


Figure 9. Static Bias Life Test Circuit (SN74HC00)

Table 1. Accelerated Life Test Results — Summary (SN74HC)

DEVICE CATEGORY	DEVICE TYPES	LOTS TESTED	UNITS TESTED	125°C DEVICE HOURS	TOTAL FAILURES	FAILURE RATE ESTIMATE (FITS)*
						0.96 eV
SSI	24	52	7,466	13,290,000	37	7.5
Flip-Flops	9	20	3,001	5,221,000	17	9.1
MSI	83	129	18,282	30,478,000	73	6.3
Totals	116	201	28,749	48,989,000	127	6.8

\*Failure rate estimate was calculated using 0.96 eV at 55°C and 60% upper confidence level.

T<sub>A</sub> = 125°C, V<sub>CC</sub> = 6 V

Table 2. Accelerated Life Test Results — SSI Circuits

Device	I <sub>CC</sub> = 4 μA					
	Dynamic			Static		
	Lots	Units	Failures	Lots	Units	Failures
SN74HC00N	2	154	1	2	154	0
SN74HC02N	9	691	1	6	462	4
SN74HC03N	7	539	1	4	308	0
SN74HC04N	1	77	1	1	77	0
SN74HC04N	2	154	1	1	77	2
SN74HC05N	1	77	0	1	77	0
SN74HC08N	1	77	0	1	77	0
SN74HC10N	1	77	3	1	76	2
SN74HC11N	1	77	0	1	77	0
SN74HC14N	1	77	1	1	77	0
SN74HC20N	1	77	0	1	77	0
SN74HC21N	1	77	0	1	77	0
SN74HC27N	1	77	0	1	77	3
SN74HC30N	2	154	0	2	154	1
SN74HC32N	3	231	2	3	231	4
SN74HC36N	1	77	0	1	77	0
SN74HC51N	1	77	0	1	77	0
SN74HC86N	1	77	0	1	77	1
SN74HC133N	3	231	2	3	231	1
SN74HC804N	2	154	1	2	154	0
SN74HC805N	1	77	0	1	77	0
SN74HC4002N	3	231	0	3	231	0
SN74HC4075N	3	231	2	3	231	0
SN74HC4078N	3	231	2	3	231	1
TOTAL (24 Devices)	52	4002	18	45	3464	19

Table 3. Accelerated Life Test Results — Flip-Flop Circuits

Device	I <sub>CC</sub> = 4 μA					
	Dynamic			Static		
	Lots	Units	Failures	Lots	Units	Failures
SN74HC74N	3	231	2	3	231	1
SN74HC75N	3	230	0	2	154	2
SN74HC76N	3	231	0	3	231	0
SN74HC77N	1	77	0	1	77	0
SN74HC107N	3	231	0	3	231	0
SN74HC109N	3	231	4	3	231	4
SN74HC112N	2	154	2	2	154	2
SN74HC113N	1	76	0	1	77	0
SN74HC114N	1	77	0	1	77	0
Total (9 Devices)	20	1538	8	19	1463	9

Table 1 is a summary of the life test results for the SN74HC family. This table includes the failure rate (in FITs) using 0.96 eV activation energy. Tables 2, 3, and 4 are the results of the accelerated life tests for SSI circuits, Flip-flop circuits and MSI circuits respectively. These tables show the results for both the dynamic and static accelerated life tests. Figure 10 illustrates the SN74HC failure rate as it relates to temperature.



Table 4. Accelerated Life Test Results  
MSI Circuits

Device	$I_{CC} = 8 \mu A$					
	Dynamic			Static		
	Lots	Units	Failures	Lots	Units	Failures
SN74HC42N	3	231	1	3	231	1
SN74HC125N	2	154	0	2	154	0
SN74HC126N	1	77	0	1	77	0
SN74HC137N	1	77	0	1	77	0
SN74HCT137N	1	77	0	1	77	0
SN74HC138N	1	77	0	1	76	0
SN74HCT138N	1	77	0	1	77	0
SN74HC139N	2	154	0	2	154	0
SN74HC151N	1	77	0	—	—	—
SN74HC152N	1	77	0	1	77	2
SN74HC153N	1	77	2	1	77	0
SN74HC157N	1	77	0	1	77	1
SN74HC158N	1	77	0	1	77	0
SN74HC160N	3	231	1	3	231	2
SN74HC161N	4	308	0	3	231	0
SN74HC164N	2	122	0	1	77	0
SN74HC165N	3	230	0	3	231	1
SN74HC166N	3	231	1	3	231	1
SN74HC173N	1	77	0	1	77	0
SN74HC174N	1	77	0	1	77	0
SN74HC175N	2	154	0	2	152	0
SN74HC180N	1	77	0	1	77	0
SN74HC190N	1	77	0	—	—	—
SN74HC191N	1	77	0	1	77	1
SN74HC192N	1	77	0	—	—	—
SN74HC193N	1	77	0	—	—	—
SN74HC194N	2	154	0	2	154	0
SN74HC195N	1	77	0	1	77	0
SN74HC237N	1	77	0	1	77	0
SN74HCT237N	1	77	0	1	77	0
SN74HC238N	1	77	0	1	77	0
SN74HCT238N	1	77	0	1	77	0
SN74HC239N	1	77	0	1	77	0
SN74HC240N	4	307	1	1	77	1
SN74HCT240N	1	77	1	1	77	0
SN74HC241N	5	380	0	—	—	—
SN74HCT241N	1	77	0	1	77	1
SN74HC242N	2	154	0	1	77	0
SN74HCT242N	1	77	2	1	77	0
SN74HCT243N	1	77	2	1	77	2
SN74HC244N	3	231	0	1	77	0
SN74HCT244N	1	77	2	1	77	0
SN74HC245N	1	77	0	1	77	0

Table 4. Accelerated Life Test Results  
MSI Circuits (Continued)

Device	$I_{CC} = 8 \mu A$					
	Dynamic			Static		
	Lots	Units	Failures	Lots	Units	Failures
SN74HC253N	1	77	0	1	77	0
SN74HC257N	1	77	2	1	77	0
SN74HC258N	1	77	0	1	77	0
SN74HC259N	2	154	0	2	154	1
SN74HC273N	2	154	0	2	154	0
SN74HC280N	2	154	0	2	154	0
SN74HC298N	3	231	2	3	231	1
SN74HC352N	1	77	0	1	77	0
SN74HC353N	1	77	1	1	77	0
SN74HC365N	4	308	2	4	308	1
SN74HC366N	1	77	2	1	77	0
SN74HC367N	1	77	0	1	77	0
SN74HC368N	1	77	0	1	77	0
SN74HC373N	3	231	0	1	77	0
SN74HC374N	1	77	0	1	77	2
SN74HC377N	2	154	0	1	77	0
SN74HC378N	1	77	0	1	77	0
SN74HC379N	1	77	1	1	77	0
SN74HC390N	1	77	0	1	77	0
SN74HC393N	1	77	0	1	77	0
SN74HC490N	1	77	0	1	77	0
SN74HC563N	2	154	0	2	154	0
SN74HCT563N	1	76	0	1	77	0
SN74HC564N	1	77	0	1	77	0
SN74HCT564N	1	77	1	1	77	1
SN74HC573N	1	77	1	1	77	0
SN74HCT573N	1	77	0	1	77	0
SN74HC574N	1	77	3	1	77	0
SN74HC604N	3	231	3	3	231	4
SN74HC620N	1	77	0	1	77	0
SN74HC623N	1	77	0	1	77	0
SN74HC640N	1	77	1	1	77	3
SN74HC643N	1	77	0	1	77	0
SN74HC645N	5	384	0	5	385	5
SN74HC4020N	1	77	0	1	77	0
SN74HC4024N	3	231	2	3	231	1
SN74HC4040N	1	77	0	1	77	1
SN74HC4060N	1	77	2	1	77	0
SN74HC4061N	1	77	0	1	77	1
SN74HC4724N	1	77	1	1	77	0
Total (83 Devices)	129	9892	38	109	8390	35

QUALITY AND RELIABILITY



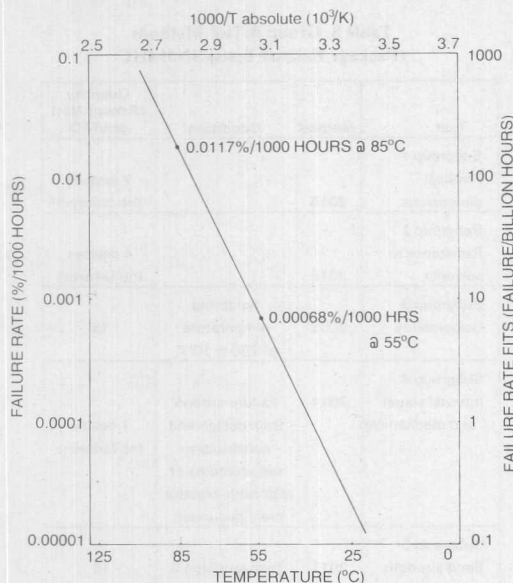


Figure 10. Failure Rate vs. Temperature  
Based on 0.96 eV

#### BIAS TEMPERATURE HUMIDITY LIFE TESTS

Bias temperature humidity life testing is designed to evaluate the moisture-related performance of the package-die combination. It is performed at a 6-V bias voltage at 85°C and 85% relative humidity using the same circuit as the static bias life test. Electrical measurements are conducted at 0, 168, 500, and 1000 hours. This is an accelerated test and uses stress levels considerably in excess of normal field use. The test is designed to accelerate moisture-related failure mechanisms occurring over many years of field use. Acceleration factors for metal corrosion between 85°C and 85% RH and several typical use conditions are shown in Table 5<sup>1</sup>. Table 6 summarizes the test results and lists the percent failures at 1000 hours by category.

Table 5. Acceleration Factor (AF) for  
85/85 vs. Use Conditions

Temp (°C)	RH %	AF
25	60	1346
40	40	29570
25	40	110552

<sup>1</sup> Based on "Reliability Evaluation of Aluminium-Metalized MOS Dynamic Rams in Plastic Packages in High Humidity and Temperature Environments" by Kurt Striny and Arthur Schelling, Bell Labs, Allentown, PA.

Table 6. Bias Temperature  
Humidity Life Test Results — Summary (SN74HC)  
T<sub>A</sub> = 85°C, RH = 85%, V<sub>CC</sub> = 6 V

Device Category	Device Types	Lots Tested	Units Tested	Failures	Percent Failures At 1000 Hours
SSI	21	46	3,934	39	0.99
Flip-Flop	8	20	1,741	6	0.34
MSI	67	92	7,732	94	1.22
Totals	96	158	13,407	139	1.04

This means that devices are expected to last 1346 times longer in an environment of 25°C and 60% RH than in an environment of 85°C and 85% RH. Flip-flops (Table 6) would be expected to last 1000 hours x 1346 = 1346000 hours (153 years) before 0.34% failures occurred due to metal corrosion.

#### PACKAGE/DIE RELATED TESTING

The standard volume production packaging materials include leadframes, mounting material, and molding compound. Although the standard materials are previously qualified, compatibility verification testing is conducted to provide a measure of confidence that the materials are compatible with Silicon-gate High-speed CMOS technology. A brief description of these Package/Die related tests is given and the results summarized in Table 7.

Table 7. Package/Die  
Related Tests On Dual-In-Line-Plastic (SN74HC)

Test	Conditions	Units Tested	Failures	Failure Rate (%)
Power Temperature Cycle	-40°C to 85°C 2000 Hours On/Off 5 Secs	2,282	3	0.13
Extended Temperature Cycle	-65°C to 150°C 1000 Cycles	8,149	23	0.28
Storage Life	150°C 2000 Hours	13,389	27	0.20
Pressure Cooker	15 psig 240 Hours	15,596	173	1.11
Extended Thermal Shock	0°C to 100°C 500 Cycles	4,613	2	0.04
Electrostatic Discharge Sensitivity	MIL-STD-883B Method 3015.1 2000 Volts	2,592	86	3.32

#### Power Temperature Cycle

This is an accelerated reliability test used to evaluate the effect of thermal stress induced on the device by cycling the power on and off. Devices are cycled from -40°C to 85°C with the voltage bias alternately applied and removed.

### Extended Temperature Cycle

This is an accelerated reliability test used to determine the thermal expansion compatibility of the materials used in device construction. The test calls for cycling (1000 cycles) the devices in an ambient air temperature environment from -65°C to 150°C. No bias is applied to the devices.

### Storage Life

This reliability test is used to accelerate temperature sensitive failure mechanisms. Units are placed in an environment at 150°C for 1000 hours with no bias applied.

### Pressure Cooker

This is a highly accelerated moisture test consisting of 100% relative humidity and 121°C at 15 psig. While no valid acceleration factor has been determined between these conditions and actual use temperature and humidity, the test is useful to compare high humidity performance of plastic packaged circuits.

### Extended Thermal Shock

This accelerated reliability test is similar to temperature cycling, except temperature transitions are very rapid (typically several seconds) from 0°C to 100°C and a liquid medium is used.

## SNJ54HC LOGIC FAMILY

The Military Products Department of Texas Instruments Incorporated supplies military versions of the High-speed CMOS logic family. These devices are available in the military temperature range or screened to the Class B requirements of MIL-STD-883. All SNJ54HC devices are processed and screened per JEDEC STD 101.

### TEST METHODS

In addition, MIL-STD-883, Method 5005, Class B is the guideline utilized for Groups B, C, and D testing to support the Texas Instruments 883B processed integrated circuits program. Tables 8, 9 and 10 summarize the test methods utilized for Groups B, C and D respectively. For further information refer to MIL-STD-883, Method 5005, Class B detail specification.

### TEST RESULTS

Due to the recent introduction, only limited data is now available for this logic family. Qualification data for the five microcircuit groups assigned to the High-speed CMOS logic family is shown Table 12. Tables 11 and 13 summarize the test results for Groups B and D respectively by package type.

The generic reliability failure rate estimate to date for the military version of the High-speed CMOS logic family is 6.3 FITs at 55°C using 0.96 eV activation energy

**Table 8. Group B Test Methods  
(Package Related Tests) SNJ54HC**

Test	Method	Condition	Quantity (Accept No.) or LTPD
Subgroup 1 Physical dimensions	2016		2 devices (no failures)
Subgroup 2 Resistance to solvents	2015		4 devices (no failures)
Subgroup 3 Solderability	2003	Soldering temperature of 260 ± 10°C	15
Subgroup 4 Internal visual and mechanical	2014	Failure criteria from design and construction requirements of applicable procure- ment document	1 device (no failures)
Subgroup 5 Bond strength Ultrasonic or wedge	2011	Test condition C or D	15
Subgroup 6 Internal water- vapor content	1018	Not applicable. No package desiccant used. Performed in subgroup D-6	
Subgroup 7 Seal (a) Fine (b) Gross	1014	As applicable	5

and 60% upper confidence level. Additional reliability testing is underway at Texas Instruments and these results will be made available in future publications.

**Table 9. Group C Methods  
(Die Related Tests) SNJ54HC**

Test	Method	Condition	Quantity (Accept No.) or LTPD
Subgroup 1 Steady State Life Test End Point Electrical Parameters	1005	184 Hrs at 150°C Or 1000 Hrs at 125°C	5
Subgroup 2 Temperature Cycling Constant Acceleration Seal (a) Fine (b) Gross Visual Examination End Point Electrical Parameters	1010  2001 1014   1010/ 1011	Test Condition C  Test Condition E As Applicable	15

**Table 10. Group D Test Methods  
(Package Related Tests) SNJ54HC**

TEST METHODS			
Test	Method	Condition	Quantity (Accept No.) or LTPD
Subgroup 1 (a) Physical dimensions	2016		15
Subgroup 2 Lead integrity  Seal (a) Fine (b) Gross Lid Torque	2004  1014  2024	Test condition B2 (lead fatigue) As applicable  As applicable	15
Subgroup 3 Thermal shock  Temperature cycling  Moisture resistance Seal (a) Fine (b) Gross	1011  1010  1004 1014	Test condition B, 15 cycles minimum.  Test condition C, 100 cycles minimum  As applicable	15

**Table 10. Group D Test Methods  
(Package Related Tests) SNJ54HC (Cont.)**

TEST METHODS			
Test	Method	Condition	Quantity (Accept No.) or LTPD
Subgroup 3 (cont.) Visual examination  End-point electrical parameters		Per visual criteria of Method 1004 and 1010.  As specified in the TI device data book	
Subgroup 4 Mechanical shock Vibration, variable frequency Constant acceleration  Seal (a) Fine (b) Gross Visual examination End-point electrical parameters	2002  2007 2001  1014	Test condition B  Test condition A  Test condition E, Y <sub>1</sub> orientation only As applicable  As specified in the TI device data book	15
Subgroup 5 Salt atmosphere Seal (a) Fine (b) Gross Visual Examination	1009 1014	Test condition A As applicable  Per visual criteria of Method 1009	15
Subgroup 6 Internal water-vapor content	1018	5,000 ppm maximum water content at 100°C.	3 devices (0 failures) or 5 devices (1 failure)
Subgroup 7 Adhesion of Lead Finish	2025		15

Subgroup		14-Lead Ceramic Dual-In-Line (J)	16-Lead Ceramic Dual-In-Line (J)	20-Lead Ceramic Dual-In-Line (J)	20-Pad Ceramic Leadless Type C Chip Carrier (FK)	24-Lead Ceramic Dual-In-Line (J)
B-1	Number Tested	40	86	48	66	20
	Number Failures	0	0	0	0	0
B-2	Number Tested	80	132	96	132	40
	Number Failures	0	0	0	1	0
B-3	Number Tested	490	825	600	825	34
	Number Failures	0	0	0	0	0
B-4	Number Tested	20	33	24	33	10
	Number Failures	0	0	0	0	0
B-5	Number Tested	101	294	138	321	61
	Number Failures	0	0	0	0	0
B-7	Number Tested	450	270	45	450	125
	Number Failures	0	0	0	0	0

## CONCLUSION

Through the successful execution of an aggressive designed-in reliability program, Texas Instruments Incorporated introduced the High-speed Silicon-gate CMOS logic family with a reliability consistent with that of mature products already in the market. Extensive reliability characterization programs required for the introduction of a new technology to the market place are fully satisfied by this logic family.

Overall, the generic reliability failure rate estimate for SN74HC High-speed CMOS technology is 6.8 FITs at 55°C using 0.96 eV activation energy and 60% upper confidence level.

Texas Instruments' commitment to quality ensures continued reliability testing of this nature on new devices as they are designed and introduced. Further, a quality

Table 12. Group C Test Results SNJ54HC

MCG	Subgroup C-1		Subgroup C-2	
	Devices Tested	Failures	Devices Tested	Failures
36	77	0	25	0
37	77	0	25	0
38	77	0	25	0
39	77	0	25	0
40	77	0	25	0

Table 13. Group D Test Results SNJ54HC

Subgroup		Package Type				
		14-Lead Ceramic Dual-In-Line (J)	16-Lead Ceramic Dual-In-Line (J)	20-Lead Ceramic Dual-In-Line (J)	20-Pad Ceramic Leadless Type C Chip Carrier (FK)	24-Lead Ceramic Dual-In-Line (J)
D-1	Number Tested	30	30	15	30	15
	Number Failures	0	0	0	0	0
D-2	Number Tested	50	50	25	—	25
	Number Failures	0	0	0	—	0
D-3	Number Tested	50	50	25	72	25
	Number Failures	0	0	0	2	0
D-4	Number Tested	50	50	25	50	25
	Number Failures	0	0	0	0	0
D-5	Number Tested	50	50	25	50	25
	Number Failures	0	0	0	0	0
D-6	Number Tested	10	10	5	10	5
	Number Failures	0	0	0	0	0
D-7	Number Tested	40	40	25	—	15
	Number Failures	0	0	0	—	0
D-8	Number Tested	15	15	—	—	15
	Number Failures	0	0	—	—	0

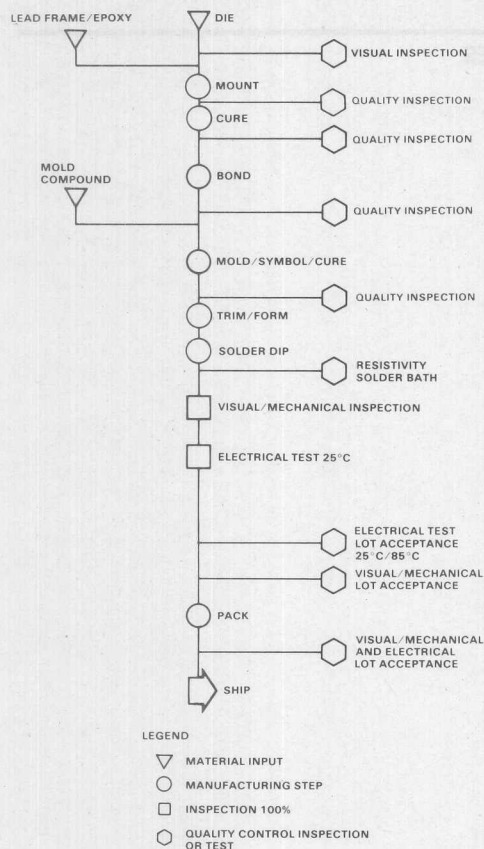


Figure 11. Typical SN74HC Flow Diagram

watch program to monitor the quality and reliability of production devices is in place, and guarantees a product of the highest quality on an ongoing basis. Texas Instruments plans to publish these results as a formal report on a continuing basis. See Figure 11 for a typical SN74HC flow diagram.

If any additional quality and reliability related information is required, contact your nearest TI sales office.

## ELECTROSTATIC DISCHARGE DAMAGE

All semiconductors are sensitive to electrostatic discharge damage at some voltage level. Many-hard-to-identify failures at incoming, board assembly, equipment assembly, and in the field are due to ESD. In order to improve the reliability of a design, it is important to identify the devices that are more sensitive to ESD damage so that special care may be taken to prevent ESD damage and subsequent failure.

TI has implemented a comprehensive electrostatic discharge (ESD) control program. Part of this program requires testing of the various product families for ESD sensitivity in accordance with Method 3015 of MIL-STD-883. Products that are ESD sensitive to 2 kV or less (category A) have been identified. These products have special protective packaging and carry electrostatic sensitive labels. For maximum quality and reliability of these devices, appropriate ESD handling procedures from incoming through final assembly and shipment should be followed at the user site as well.

The ESD sensitivity level of products can be improved by special protection circuitry. This is a major design consideration at TI on all new and revised products. However, this by itself will not solve the ESD problem. Protective circuits will typically raise the ESD sensitivity level to 3 kV to 4 kV. Most stockrooms, incoming inspection areas, and assembly areas have static voltages present which are well above 10 kV — unless special ESD precautions have been implemented. So even when the IC manufacturer provides maximum ESD sensitivity protection, it is still necessary for the end user to implement ESD controls to eliminate the high static voltage levels normally found in his process. Through a cooperative effort between the IC manufacturer and the end user, quality and reliability of IC's can be improved by reducing/eliminating ESD damage.



